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ABSTRACT

To assist teachers and students in understanding the latest concepts and functions of the automobile, this curriculum guide treats both the skills and knowledge necessary for auto mechanics. Developed by an advisory committee of instructors and mechanics in the industry, this manual consists of the following four sections: engine rebuilding; electrical systems; drive train; and accessories such as air conditioning and heaters. Each section contains several instructional units which are organized into eight parts: (1) student behavioral objectives, which state the goals of the course; (2) suggested activities, outlining steps for both students and instructors to accomplish specific objectives; (3) information sheets, which provide the content necessary to meet the knowledge objectives of the unit; (4) job sheets which outline the skills being taught; (6) assignment sheets for homework or classroom use (answer sheets are also included); (7) paper-pencil and performance tests constructed to measure student achievement of each objective; and (8) test answers. (ELG)

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AUTO MECHANICS

VOLUME II

Instructional Units

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State Department of Vocational and Technical Education
Stillwater, Oklahoma

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
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TABLE OF CONTENTS

Section A--Engine Rebuilding

Unit I Engine Condition Evaluation 1-A
Unit II Engine Removal 35-A
Unit III Engine Disassembly 75-A
Unit IV Valve Train and Cylinder Head Reconditioning 97-A
Unit V Engine Crankshaft, Bearings, and Oil Pump 185-A
Unit VI Cylinder and Piston Reconditioning 249-A
Unit VII Engine Reassembly 313-A
Unit VIII Engine Installation 357-A

Section B--Electrical Systems

Unit I Basic Electrical Theory 1-B
Unit II Battery Service 57-B
Unit III Starting System 95-B
Unit IV Ignition System 165-B
Unit V Charging System 249-B
Unit VI Chassis Wiring 315-B

Section C--Drive Train

Unit I Clutch Assembly 1-C
Unit II Standard Transmission 43-C
Unit III Drive Lines 97-C
Unit IV Rear Axle 159-C
Unit V Automatic Transmission Service 239-C

Section D--Accessories

Unit I Air Conditioning 1-D
Unit II Heaters 87-D

FOREWORD

This publication is another in a series of trade and industrial curriculum materials designed to assist the instructor and his/her students to understand the latest concepts and functions of the automobile. This guide will improve the quality of material presented in the shop or classroom and will bridge the gap between learning and doing. *Auto Mechanics: Volume Two* has been developed by many dedicated teachers and skilled mechanics who have proven the materials workable in their own shops and classrooms. These committee members are to be commended for their tireless efforts to make this publication a usable tool of instructional techniques to better prepare the student for the challenges of the "world of work."

Roy E. Ayres, State Supervisor
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PREFACE

The importance of providing every student who is enrolled in an auto mechanics training program with the very best and most complete basic training possible cannot be over-emphasized. *Auto Mechanics: Volume II* is a continuation of the effort to provide an up-to-date, comprehensive instructional materials package for the auto mechanics instructors. Effective instructional materials are vital in providing a program of systematic training that will enable each student in class to reach the basic level of knowledge and skills necessary to enjoy the success of meaningful employment.

Every effort has been made to make this publication basic, readable, and by all means, usable. The instructor must motivate, supplement, localize, and personalize this material to make it a vital part of the teaching-learning process.

Ivan Armstrong, Curriculum Specialist
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USE OF THIS PUBLICATION

Instructional Units

Auto Mechanics: Volume Two includes four areas. Each area consists of two or more units of instruction. Each instructional unit includes behavioral objectives, suggested activities for teacher, information sheets, assignment sheets, job sheets, visual aids, tests, and answers to the test. Units are planned for more than one lesson or class period of instruction.

Careful study of each instructional unit by the teacher will help determine:

A. The amount of material that can be covered in each class period
B. The skills which must be demonstrated
    1. Supplies needed
    2. Equipment needed
    3. Amount of practice needed
    4. Amount of class time needed for demonstrations
C. Supplementary materials, such as pamphlets and filmstrips, that must be ordered
D. Resource people who must be contacted

Objectives

Each unit of instruction is based on behavioral objectives. These objectives state the goals of the course, thus providing a sense of direction and accomplishment for the student.

Behavioral objectives are stated in two forms: unit objectives, stating the subject matter to be covered in a unit of instruction; and specific objectives, stating the student performance necessary to reach the unit objective.

Since the objectives of the unit provide direction for the teaching-learning process, it is important for the teacher and students to have a common understanding of the intent of the objectives. A limited number of performance terms have been used in the objectives for this curriculum to assist in promoting the effectiveness of the communication among all individuals using the materials.

Following is a list of performance terms and their synonyms which may have been used in this material:

Name	Identify	Describe
Label	Select	Define
List in writing	Mark	Discuss in writing
List orally	Point out	Discuss orally
Letter	Pick out	Interpret
Record	Choose	Tell how
Repeat	Locate	Tell what
Give		Explain

Order
Arrange
Sequence
List in order
Classify
Divide
Isolate
Sort

Distinguish
Discriminate

Construct
Draw
Make
Build
Design
Formulate
Reproduce
Transcribe
Reduce
Increase
Figure

Demonstrate
Show your work
Show procedure
Perform an experiment
Perform the steps
Operate
Remove
Replace
Turn off/on
(Dis) assemble
(Dis) connect

Reading of the objectives by the student should be followed by a class discussion to answer any questions concerning performance requirements for each instructional unit.

Teachers should feel free to add objectives which will fit the material to the needs of the students and community. When a teacher adds objectives, he/she should remember to supply the needed information, assignment and/or job sheets, and criterion tests.

Suggested Activities

Each unit of instruction has a suggested activities sheet outlining steps to follow in accomplishing specific objectives. Duties of the instructor will vary according to the particular unit. However, for best use of the material they should include the following: provide student with objective sheet, information sheet, assignment sheets, and job sheets; preview filmstrips, make transparencies, and arrange for resource materials and people; discuss unit and specific objectives and information sheet; give test. Teachers are encouraged to use any additional instructional activities and teaching methods to aid students in accomplishing the objectives.

Information Sheet

The information sheet provides content essential for meeting the cognitive (knowledge) objectives of the unit. The teacher will find that the information sheet serves as an excellent guide for presenting the background knowledge necessary to develop the skill specified in the unit objective.

Students should read the information sheet before the information is discussed in class. Students may take additional notes on the information sheet.

Transparency Masters

Transparency masters provide information in a special way. The students may see as well as hear the material being presented, thus reinforcing the learning process. Transparencies may present new information or they may reinforce information presented in the information sheet. They are particularly effective when identification is necessary.

Transparencies should be made and placed in the notebook where they will be immediately available for use. Transparencies direct the class's attention to the topic of discussion. They should be left on the screen only when topics shown are under discussion. (NOTE: Stand away from the overhead projector when discussing transparency material. The noise of the projector may cause the teacher to speak too loudly.)

Assignment Sheets

Assignment sheets give direction to study and furnish practice for paper and pencil activities to develop the knowledges which are necessary prerequisites to skill development. These may be given to the student for completion in class or used for homework assignments. Answer sheets are provided which may be used by the student and/or teacher for checking student progress.

Job Sheets

Job sheets are an important segment of each unit. The instructor should be able to and in most situations should demonstrate the skills outlined in the job sheets. Procedures outlined in the job sheets give direction to the skill being taught and allow both student and teacher to check student progress toward the accomplishment of the skill. Job sheets provide a ready outline for a student to follow if she/he has missed a demonstration. Job sheets also furnish potential employers with a picture of the skills being taught and the performances he/she might reasonably expect from a person who has had this training.

Test and Evaluation

Paper-pencil and performance tests have been constructed to measure student achievement of each objective listed in the unit of instruction. Individual test items may be pulled out and used as a short test to determine student achievement of a particular objective. This kind of testing may be used as a daily quiz and will help the teacher spot difficulties being encountered by students in their efforts to accomplish the unit objective. Test items for objectives added by the teacher should be constructed and added to the test.

Test Answers

Test answers are provided for each unit. These may be used by the teacher and/or student for checking student achievement of the objectives.

Page Numbering System

Each section in this publication is assigned a specific letter: (A) Engine Rebuilding; (B) Electrical Systems; (C) Drive Train; (D) Accessories. Pages are numbered consecutively within each section. For example, Engine Rebuilding covers pages 1-A through 376-A. If the page is available as a transparency master, TM appears at the bottom of the page.

The following key will help to easily identify each section by color:

White - Objectives, Suggested Activities, and Transparency Masters

Green - Information Sheets

Buff - Assignment Sheets

Blue - Job Sheets

Yellow - Tests

Pink - Answers to Assignment Sheets and Answers to Tests

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(NOTE: This is an alphabetized list of the publications used in completing this manual.)

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ENGINE CONDITION EVALUATION
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to list items and conditions that cause engines to have low oil pressure and consume oil. The student should be able to complete a chart on internal engine noise diagnosis and perform compression and cylinder leakage tests. This knowledge will be evidenced through demonstration and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with engine condition evaluation to the correct definitions.
2. Select from a list conditions causing low oil pressure.
3. List conditons that cause oil consumption.
4. Select from a list items to inspect for engine condition evaluation.
5. Select from a list items to check prior to testing for internal engine noise.
6. Complete a chart on internal engine noise by writing the method of distinguishing the noise when given the type of noise.
7. Demonstrate the ability to:
    a. Test engine compression.
    b. Perform cylinder leakage test.

ENGINE CONDITION EVALUATION
UNIT I

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information, assignment, and job sheets.

   C. Secure material and equipment for job sheet demonstrations.

   D. Discuss unit and specific objectives.

   E. Discuss information and assignment sheets.

   F. Demonstrate and discuss procedures outlined on the job sheets.

   G. Evaluate student performance of job sheets.

   H. Give test.

II. Unit references:

   A. Ellinger, Herbert E. *Automechanics.* Englewood Cliffs, New Jersey: Prentice-Hall Inc., 1975.

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   F. *Ford Service Manual.* Dearborn, Michigan: Ford Motor Co., 1975-76.

ENGINE CONDITION EVALUATION
UNIT I

INFORMATION SHEET

I. Terms and definitions

A. Blow-by--Leakage of unburned air-fuel mixture, and some burned gases, past the piston rings into the crankcase during the compression and power stroke

B. Bloc-chek--Special measuring device that, when inserted in the radiator filler neck of a running engine, can detect leakage of combustion gas into the cooling system

C. Crankcase ventilation system--System that permits air to flow through the engine crankcase, when the engine is running, to carry out the blow-by gases and relieve any pressure buildup

(NOTE: There are two types of crankcase ventilation systems, the draft tube and the positive crankcase ventilation system.)

D. PCV (Positive Crankcase Ventilation)--System used to recycle combustion (blow-by) gases from crankcase back to the intake manifold to prevent hydrocarbons and carbon dioxide in the blow-by gases from venting to outside air

E. Piston slap--Hollow, muffled, bell-like sound made by an excessively loose piston slapping the cylinder wall

F. Preignition--Ignition of the air-fuel mixture in the engine cylinder (by any means) before the ignition spark occurs at the spark plug, causing a knock in the cylinder

G. Detonation--Engine knock caused by an uncontrolled second explosion of gases ahead of the combustion flame front

H. Compression test--Using a pressure gauge to measure maximum pressure in the cylinder while cranking the engine with the starter to test cylinder condition

I. Cylinder leakage test--Pressurizing the cylinder on compression stroke with an external air source to gauge the percentage of leakage and to determine what part of the cylinder is causing the leak

J. Decarbonizing--Process of removing carbon from the engine either during overhaul or as a cylinder treatment with the engine running

K. Engine loading--Operating the engine under a strain by using the transmission or a dynamometer

INFORMATION SHEET

II. Conditions causing low oil pressure

- A. Worn connecting rod bearings
- B. Worn main bearings
- C. Worn camshaft bearings
- D. Worn oil pump
- E. Stuck oil pressure regulator valve
- F. Broken pressure regulator valve spring in oil pump
- G. Oil pump pickup screen raised above oil level in oil pan
- H. Leakage in valve train such as a broken push rod, rocker arm, or hydraulic lifter
- I. Excessively thin or diluted oil

III. Conditions that cause oil consumption

- A. Worn or stuck piston rings
- B. Worn rod bearings

  (NOTE: For every 0.001 inch [0.41 mm] of excessive rod bearing clearance, the oil slung from the bearing increases four times. This increases the amount of oil on the cylinder walls to such a degree that even good rings will not be able to wipe it off, thus allowing oil to reach the combustion chamber and be burned.)
- C. Worn valve guides
- D. Damaged or broken valve stem seals
- E. Stuck PCV valve
- F. Leaking intake manifold gasket

  (NOTE: This condition will occur on engines that have the intake manifold covering the valve lifter chamber.)
- G. External oil leaks
- H. Vacuum diaphragm leaking on a double diaphragm fuel pump

IV. Items to inspect for engine condition evaluation

- A. Oil for water and/or fuel contamination
- B. Spark plugs for types of deposits on electrodes

  (NOTE: Refer to a spark plug chart to determine cause of plug condition.)
- C. Cooling system for compression leaks

  (NOTE. Use block-chek or Job Sheet #3 to check for compression leak into coolant.)
- D. Tail pipe for color and type of deposits

  Examples: Normal - Light to medium gray

  Excessive oil burning - Dark gray

  Excessive fuel burning - Black

  Coolant in cylinder - White to whitish brown
- E. Location of oil leaks
- F. Location of coolant leaks
- G. Positive crankcase ventilation system for excessive blow-by
- H. Air filter for evidence of dust abrasives entering engine through the intake manifold

V. Items to check prior to testing for internal engine noise

- A. Fan or accessory drive belts for cracks or missing sections of the belt core
- B. Noise in accessory components

  Examples: Alternator, air pump, air conditioning compressor
- C. Torsional vibration damper for looseness or improper installation
- D. Flywheel or torque converter drive plate for loose bolts
- E. Torque converter drive plate for cracks between the hub area and the converter attaching bolts
- F. Heat riser valve for broken spring
- G. Carbon deposits in cylinders

VI. Internal engine noise diagnosis (Assignment Sheet #1)

(NOTE: Test the following components with the engine at normal operating temperature.)

Component Making Noise	Type of Noise	Method of Distinguishing Noise
Fuel pump	Sharp, distinct, high-pitched knock localized in the fuel pump area; knock may be intermittent	Listen to the fuel pump and surrounding area with a stethoscope; noise should be loudest at the fuel pump
Valve train	Variety of light to moderate knocks, chatters, pecks, or squeaks (NOTE: Valve noises are normally at half speed of engine speed while piston, rod, and crankshaft noises will be at engine speed.)	Remove valve cover and inspect valve train for broken or bent push rods, rocker arms, or valve springs; start engine and observe valve operation; check each valve for excessive lash
Rod bearing	Very sharp, solid knock in lower part of engine, much like hitting a solid steel bar with a hammer	Run the engine at fast idle (1,500-2,000 rpm) with no load and the bearing will knock; load engine and the knock should lessen or totally disappear; with engine at idle, remove and replace one spark plug wire at a time and listen to the knock; when the cylinder with the knocking bearing has the wire removed, you will hear a double knock; then as the wire is replaced, the single knock will be heard again

Component Making Noise	Type of Noise	Method of Distinguishing Noise
Main bearing	Deep, solid knock that at higher engine speeds will sound like a heavy rumbling noise (NOTE: A broken crankshaft will sound very similar to a main bearing noise.)	Load the engine at fast idle; knock will increase with load and decrease as the load is relieved (NOTE: Rod and/or main bearing is accompanied by low oil pressure. In some cases, the engine will consume more oil because of the added oil slung from the bearing onto the cylinder walls.)
Piston knock	Very hollow, higher pitched, light to moderate knock	Start engine cold and let fast idle until operating temperature is reached (piston noise will tend to lessen as engine warms up); with engine speed set to loudest knock, remove and replace one spark plug wire at a time until the knock stops, indicating the cylinder with the knocking piston
Wrist pin	Solid knock, but lighter than rod or main bearings and usually double in frequency (NOTE: It knocks at both top and bottom of each stroke.)	Raise and lower the engine speed lightly and listen for the knock to become more severe as engine is accelerated; double knock will be about equal on deceleration

Component Making Noise	Type of Noise	Method of Distinguishing Noise
Timing chain ●	Clicking or peaking noise much like a valve lifter which remains consistently loud as engine speeds vary but changes frequency with engine speed	Operate the engine at fast idle and listen to the timing cover and general area around it with a stethoscope; noise should be louder on the cover

(CAUTION: At no time should an engine with a knock be tested at speeds above 2,500 rpm.)

Complete the following chart for troubleshooting internal engine noise.

Component Making Noise	Type of Noise	Method of Distinguishing Noise
	Very sharp, solid knock in lower part of engine, much like hitting a solid steel bar with a hammer	
	Variety of light to moderate knocks, chatters, pecks, or squeaks	

Component Making Noise	Type of Noise	Method of Distinguishing Noise
	Sharp, distinct, high-pitched knock localized in the fuel pump area; knock may be intermittent	
	Deep, solid knock that at higher engine speeds will sound like a heavy rumbling noise	
	Clicking or peaking noise much like a valve lifter which remains consistently loud as engine speeds vary but changes frequency with engine speed	

Component Making Noise	Type of Noise	Method of Distinguishing Noise
	Very hollow, higher pitched, light to moderate knock	
	Solid knock, but lighter than rod or main bearings and usually double in frequency	

ASSIGNMENT SHEET #1

ANSWERS TO ASSIGNMENT SHEET #1

Component Making Noise	Type of Noise	Method of Distinguishing Noise
Rod bearing	Very sharp, solid knock in lower part of engine, much like hitting a solid steel bar with a hammer	Run the engine at fast idle (1,500-2,000 rpm) with no load and the bearing will knock; load engine and the knock should lessen or totally disappear; with engine at idle, remove and replace one spark plug wire at a time and listen to the knock; when the cylinder with the knocking bearing has the wire removed, you will hear a double knock; then as the wire is replaced, the single knock will be heard again
Valve train	Variety of light to moderate knocks, chatters, pecks, or squeaks	Remove valve cover and inspect valve train for broken or bent push rods, rocker arms, or valve springs; start engine and observe valve operation; check each valve for excessive lash
Fuel pump	Sharp, distinct, high-pitched knock localized in the fuel pump area; knock may be intermittent	Listen to the fuel pump and surrounding area with stethoscope; noise should be loudest at the fuel pump
Main bearing	Deep, solid knock that at higher engine speeds will sound like a heavy rumbling noise	Load the engine at fast idle; knock will increase with load and decrease as the load is relieved

Component Making Noise	Type of Noise	Method of Distinguishing Noise
Timing chain	Clicking or peaking noise much like a valve lifter which remains consistently loud as engine speeds vary but changes frequency with engine speed	Operate the engine at fast idle and listen to the timing cover and general area around it with a stethoscope; noise should be louder on the cover
Piston knock	Very hollow, higher pitched, light to moderate knock	Start engine cold and let fast idle until operating temperature is reached (piston noise will tend to lessen as engine warms up); with engine speed set to loudest knock, remove and replace one spark plug wire at a time until the knock stops, indicating the cylinder with the knocking piston
Wrist pin	Solid knock, but lighter than rod or main bearings and usually double in frequency	Raise and lower the engine speed lightly and listen for the knock to become more severe as engine is accelerated; double knock will be about equal on deceleration

ENGINE CONDITION EVALUATION
UNIT I

JOB SHEET #1--TEST ENGINE COMPRESSION

I. Tools and equipment

   A. Basic hand tool set

   B. Compression gauge

   C. Squirt can with 30 W oil

   D. Fender covers, 2

   E. Safety glasses

   F. Remote starter switch

   G. Stethoscope or other listening device

   H. Compression specifications for the particular engine being serviced

II. Procedure

   A. Prepare engine for compression test

      1. Operate engine until normal operating temperature is obtained

      2. Remove air cleaner

      3. Remove ignition coil secondary lead from center tower of distributor cap and connect to a good ground

         (NOTE: On the HEI electronic ignition, disconnect the distributor primary load wire while the ignition switch is in the off position.)

      4. Block the carburetor throttle valve and choke valve in the wide-open position

         (CAUTION: Make sure that automatic transmission models are in Park and standard transmissions are in Neutral with the park brake set.)

      5. Remove all spark plugs

         (NOTE: Clean around the spark plugs before removing them so that dirt does not fall into the engine as they are removed. This can be done by loosening the spark plugs two or three turns and cranking the engine a few revolutions.)

      6. Test battery condition and charge as necessary to provide consistently strong engine cranking during the test

JOB SHEET #1

B. Make a record sheet similar to Figure 1 to use during compression testing

FIGURE 1

Record Sheet For Compression Testing

Cylinder Number	Dry Test Gauge Reading	Wet Test Gauge Reading	Test Results

C. Perform dry compression test

1. Connect remote starter switch to starter solenoid or relay
2. Install compression gauge hose in No. 1 cylinder
3. Connect gauge to hose
4. Crank engine to obtain five compression strokes of the engine as indicated by fluctuation of gauge hand
5. Record the gauge reading next to No. 1 cylinder on record sheet
6. Repeat steps 3 through 6 on each of the remaining cylinders

   (NOTE: Obtain compression specifications for the particular engine being serviced. Compression readings should not vary among cylinders more than 15 psi [2.155 kPa] and should not drop more than 15% below specified pressure.)

JOB SHEET #1

D. Perform a wet compression test

1. Inject approximately 2 tablespoons (30 mL) of 30 W motor oil in each cylinder
2. Connect a remote starter switch to the starter solenoid or relay
3. Install compression gauge hose in No. 1 cylinder
4. Connect hose to gauge
5. Crank engine to obtain five compression strokes of the engine as indicated by the fluctuation of the gauge hand
6. Record the gauge reading next to No. 1 cylinder on the record sheet
7. Repeat steps 4 through 7 on each of the remaining cylinders

E. Compare the dry compression test with the wet compression test

(NOTE: The wet compression test is used as a diagnostic tool when evaluating cylinder condition. The oil used on the wet test will seal the piston rings. If the compression rises significantly, 15 psi [2.155 kPa] or more, the rings are leaking compression. If compression does not rise, the valves or head gasket is defective.)

ENGINE CONDITION EVALUATION
UNIT I

JOB SHEET #2--PERFORM CYLINDER LEAKAGE TEST

I. Tools and equipment

   A. Basic hand tool set

   B. Cylinder leakage tester

   C. Fender covers, 2

   D. Safety glasses

II. Procedure

   A. Prepare engine for cylinder leakage test

      1. Operate engine until normal operating temperature is obtained

      2. Remove air cleaner

      3. Remove all spark plugs

         (NOTE: Clean around the spark plugs before removing them so that dirt does not fall into the engine as they are removed. This can be done by loosening the spark plug two or three turns and cranking the engine a few revolutions.)

      4. Remove ignition coil secondary lead from center tower of distributor cap and connect to a good ground

         (NOTE: On the HEI electronic ignition system, disconnect the distributor primary lead wire while the ignition switch is in the off position.)

      5. Block the carburetor throttle and choke valve in the wide-open position

      6. Remove the radiator cap

         (CAUTION: Loosen the cap and release pressure slowly before removing cap to prevent being burned by hot coolant.)

      7. Remove oil cap

JOB SHEET #2

B. Perform cylinder leakage test

1. Insert adapter into No. 1 cylinder by screwing adapter into spark plug hole (Figure 1)

2. Attach whistle to adapter in No. 1 cylinder (Figure 1)

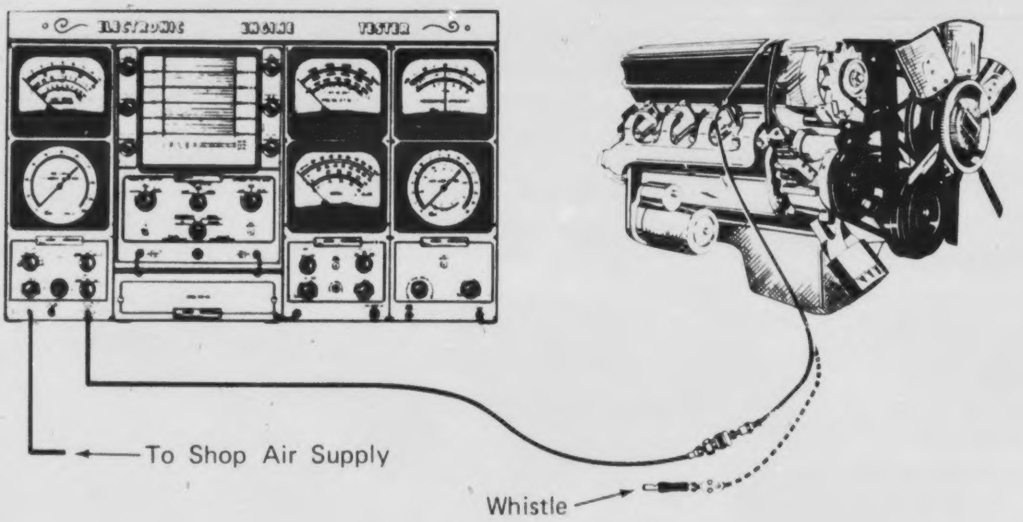
3. Rotate engine a fraction of a revolution at a time until whistle sounds

   (NOTE: The sounding whistle indicates the piston is on compression stroke. To perform the leakage test, the piston must be very close to TDC or the test air pressure will push the piston back down the cylinder. An indicator plate can be used on the distributor to indicate when each piston in firing order is in the correct position for testing.)

4. Adjust cylinder leakage tester according to manufacturer's instructions

5. Connect tester hose to adapter (Figure 1)

FIGURE 1



6. Note the percentage of leakage on the tester gauge

   (NOTE: This reading should be less than 20%. If reading is much higher, repeat Steps 1 and 2 because both valves are probably not closed completely.)

JOB SHEET #2

7. Record this reading on a chart similar to that in Figure 2

8. Listen for air escaping through the carburetor, the exhaust or tail pipe, and the crankcase filler pipe

   (NOTE: It may be necessary to use a stethoscope or other listening device to determine exact location of air leakage.)

9. Check for air bubbles in the radiator

10. Check the appropriate column in chart (Figure 2)

FIGURE 2

Check Applicable Columns Air Leakage Noticed At:					
Cylinder (By Firing Order)	Percent of Leakage	Carburetor	Exhaust Pipe	Oil Filler	Radiator

11. Test remaining cylinders in this manner

    (NOTE. Use the condition chart with the diagnosis chart below to determine possible repairs needed. In cases where high percentages of leakage are noted on engines with comparatively low mileage which could be attributed to stuck piston rings, it is advisable to treat the engine with a good grade of tune-up or break-in oil for. a period of time and then retest before recommending that the engine be disassembled for major service.)

AIR LEAKAGE LOCATION	PROBABLE CAUSES
Carburetor	Intake valve leaking
Exhaust pipe	Exhaust valve leaking
Adjacent cylinders, both showing a high percent of leakage	Leaking head gasket, crack in block or head
Radiator	Leaking head gasket, crack in cylinder block or head
Oil filler pipe	Worn rings or cylinder walls, stuck or broken rings, cracked pistons

ENGINE CONDITION EVALUATION
UNIT I

TEST

NAME ______________________________ SCORE __________________

1. Match the terms on the right to the correct definitions.

_____a. Leakage of unburned air-fuel mixture, and some burned gases, past the piston rings into the crankcase during the compression and power stroke

_____b. Special measuring device that, when inserted in the radiator filler neck of a running engine, can detect leakage of combustion gas into the cooling system

_____c. System that permits air to flow through the engine crankcase, when the engine is running, to carry out the blow-by gases and relieve any pressure buildup

_____d. System used to recycle combustion (blow-by) gases from crankcase back to the intake manifold to prevent hydrocarbons and carbon dioxide on the blow-by gases from venting to outside air

_____e. Hollow, muffled, bell-like sound made by an excessively loose piston slapping the cylinder wall

_____f. Ignition of the air-fuel mixture in the engine cylinder (by any means) before the ignition spark occurs at the spark plug, causing a knock in the cylinder

_____g. Engine knock caused by an uncontrolled second explosion of gases ahead of the combustion flame front

_____h. Using a pressure gauge to measure maximum pressure in the cylinder while cranking the engine with the starter to test cylinder condition

1. Decarbonizing
2. Engine loading
3. Preignition
4. Blow-by
5. PCV (Positive Crankcase Ventilation)
6. Bloc-chek
7. Piston slap
8. Detonation
9. Cylinder leakage test
10. Compression test
11. Crankcase ventilation system

_____i. Pressurizing the cylinder on compression stroke with an external air source to gauge the percentage of leakage and to determine what part of the cylinder is causing the leak

_____j. Process of removing carbon from the engine either during overhaul or as a cylinder treatment with the engine running

_____k. Operating the engine under a strain by using the transmission or a dynamometer

2. Select from the following list conditions that cause low oil pressure by placing an "X" in the correct blanks.

_____a. Broken pressure regulator valve spring in oil pump

_____b. Worn camshaft bearings

_____c. Worn distributor shaft bearings

_____d. Worn main bearings

_____e. Worn U-joints

_____f. Stuck oil pressure regulator valve

_____g. Worn oil pump

_____h. Oil pump pickup screen raised above oil level in oil pan

_____i. Leakage in valve train such as a broken push rod, rocker arm, or hydraulic lifter

_____j. Excessively thin or diluted oil

_____k. Low detergent oil

_____l. Worn connecting rod bearings

_____m. Stuck thermostat

3. List eight conditions that cause oil consumption.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

g. ____________________

h. ____________________

4. Select from the following list items to inspect for engine condition evaluation by placing an "X" in the correct blanks.

_____a. Clutch free-play

_____b. Location of oil leaks

_____c. Tail pipe for color and type of deposits

_____d. Air filter for evidence of dust abrasives entering engine through the intake manifold

_____e. Condition of motor mounts

_____f. Positive crankcase ventilation system for excessive blow-by

_____g. Carburetor choke operation

_____h. Oil for water and/or fuel contamination

_____i. Spark plugs for types of deposits on electrodes

_____j. Fuel pump pressure and capacity

_____k. Cooling system for compression leaks

_____l. Location of coolant leaks

5. Select from the following list items to check prior to testing for internal engine noise by placing an "X" in the correct blanks.

_____a. Carbon deposits in cylinders

_____b. Exhaust pipe gaskets

_____c. Torque converter drive plate for cracks between the hub area and the converter attaching bolts

_____d. Torsional vibration damper for looseness or improper installation

_____e. Noise in accessory components

_____f. Motor mounts

_____g. Flywheel or torque converter drive plate for loose bolts

_____h. Clutch free-play

_____i. Heat riser valve for broken spring

_____j. Fan or accessory drive belts for cracks or missing sections of the belt core

6. Complete the following chart by writing the methods of distinguishing the internal engine noises.

Component Making Noise	Type of Noise	Method of Distinguishing Noise
a. Piston knock	Very hollow, higher pitched, light to moderate knock	
b. Timing chain	Clicking or peaking noise much like a valve lifter which remains consistently loud as engine speeds vary but changes frequency with engine speed	
c. Main bearing	Deep, solid knock that at higher engine speeds will sound like a heavy rumbling noise	
d. Fuel pump	Sharp, distinct, high-pitched knock localized in the fuel pump area; knock may be intermittent	

Component Making Noise	Type of Noise	Method of Distinguishing Noise
e. Rod bearing	Very sharp, solid knock in lower part of engine, much like hitting a solid steel bar with a hammer	
f. Valve train	Variety of light to moderate knocks, chatters, pecks, or squeaks	
g. Wrist pin	Solid knock but lighter than rod or main bearings and usually double in frequency	

7. Demonstrate the ability to:

   a. Test engine compression.

   b. Perform cylinder leakage test.

   (NOTE If these activities have not been accomplished prior to the test, ask the instructor when they should be completed.)

ENGINE CONDITION EVALUATION
UNIT I

ANSWERS TO TEST

1. a. 4
   b. 6
   c. 11
   d. 5
   e. 7
   f. 3
   g. 8
   h. 10
   i. 9
   j. 1
   k. 2

2. a, b, d, f, g, h, i, j, l

3. a. Worn or stuck piston rings
   b. Worn rod bearings
   c. Worn valve guides
   d. Damaged or broken valve stem seals
   e. Stuck PCV valve
   f. Leaking intake manifold gasket
   g. External oil leaks
   h. Vacuum diaphragm leaking on a double diaphragm fuel pump

4. b, c, d, f, h, i, k, l

5. a, c, d, e, g, i, j

6. a. Start engine cold and let fast idle until operating temperature is reached (piston noise will tend to lessen as engine warms up); with engine speed set to loudest knock, remove and replace one spark plug wire at a time until the knock stops, indicating the cylinder with the knocking piston

   b. Operate the engine at fast idle and listen to the timing cover and general area around it with a stethoscope; noise should be louder on the cover

   c. Load the engine at fast idle; knock will increase with load and decrease as the load is relieved

   d. Listen to the fuel pump and surrounding area with a stethoscope; noise should be loudest at the fuel pump

   e. Run the engine at fast idle (1,500-2,000 rpm) with no load and the bearing will knock; load engine and the knock should lessen or totally disappear; with engine at idle, remove and replace one spark plug wire at a time and listen to the knock; when the cylinder with the knocking bearing has the wire removed, you will hear a double knock and then as the wire is replaced, the single knock will be heard again

   f. Remove valve cover and inspect valve train for broken or bent push rods, rocker arms, or valve springs; start engine and observe valve operation; check each valve for excessive lash

   g. Raise and lower the engine speed lightly and listen for the knock to become more severe as engine is accelerated; double knock will be about equal on deceleration

7. Performance skills evaluated to satisfaction of instructor

ENGINE REMOVAL
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to safely remove an automobile engine in an organized and efficient manner. This knowledge will be evidenced through demonstration and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with engine removal to the correct definitions.
2. Select from a list safety precautions to observe while removing an engine.
3. Identify tools and equipment used in engine removal.
4. Arrange in order the procedure for planning engine removal.
5. Demonstrate the ability to:
    a. Remove an engine with an automatic transmission.
    b. Remove an engine with a standard transmission.

ENGINE REMOVAL
UNIT II

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparency.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Take pictures of engine electrical and vacuum connections to aid in reinstallation of engine.

   G. Demonstrate and discuss procedures outlined on the job sheets.

   H. Give test.

II. Unit references:

   A. Ellinger, Herbert E. *Automechanics.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1972.

   B. Crouse, William H. *Automotive Mechanics.* 7th ed. New York: McGraw-Hill Book Co., 1975.

   C. Crouse, William H. *Automotive Engine Design.* New York: McGraw-Hill Book Co., 1970.

   D. *Chevrolet Service Manual.* Detroit: Chevrolet Motor Div./General Motors Corp., 1977.

   E. *Chrysler, Plymouth, Dodge Chassis Service Manual.* Detroit: Chrysler Corp., 1976.

   F. *Ford Service Manual.* Dearborn, Michigan: Ford Motor Co., 1975-76.

ENGINE REMOVAL
UNIT II

INFORMATION SHEET

I. Terms and definitions

   A. Bell housing--Metal covering around the flywheel and clutch or the torque converter assembly

   B. Firewall--Metal partition between the driver's compartment and engine compartment

   C. Cowel--That part of the car body between the engine firewall and the front of the dash panel

   D. Splash shield or apron--Sheet metal liner in the front fender that separates the front wheel compartment from the engine compartment

   E. Radiator support--Metal yoke between the front fenders that supports the front of the fender, radiator, and air conditioning condenser

   F. Air conditioning condenser--Component of the air conditioning system mounted in front of the radiator on the radiator support

   G. Air conditioning evaporator--Component of an air conditioning system which is mounted on the firewall of the vehicle

   H. Schrader valve--Spring-loaded valve similar to a tire valve located inside the service fitting of an air conditioning system

   I. Engine repair stand--Mobile fixture on which an engine can be mounted that allows the rotation of the engine to various positions to make repair work easier

II. Safety precautions to observe while removing an engine

   A. Determine if the hoist capacity is sufficient to handle the engine weight

   B. Stand clear of engine supported by a hoist

   C. Do not work under vehicle while lifting the engine on hoist

   (NOTE: Always work around an engine on a hoist as though it may fall at any time.)

   D. Check all equipment connections before lifting engine

   E. Tighten all lift adapter attaching bolts evenly with adapter plate held solidly against the engine surface

INFORMATION SHEET

F. Do not raise engine higher than necessary to clear vehicle

G. Lower engine to near floor level as soon as possible after removal from vehicle

H. Do not work on an engine that is supported only by a hoist

I. Be sure floor will provide adequate work room and is clean and free of obstacles that would interfere with hoist or engine movement

III. Special tools and equipment used in engine removal (Transparency 1)

A. Engine lift adapters

1. Cylinder head bolt

2. Carburetor

B. Chain hoist

C. Hydraulic lift

D. Engine or transmission support

IV. Procedure for planning engine removal

A. Prepare storage for radiator, hood, and other items removed during engine removal

B. Provide ample room for work around vehicle to include the type of hoist used

C. Remove or disconnect all items possible by working over the fender

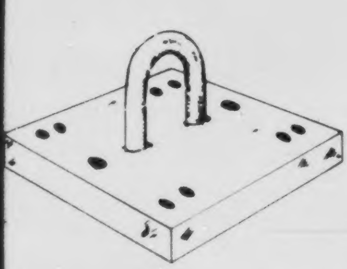
D. Keep bolts, clips, and brackets removed from each side of the engine compartment in separate, marked parts trays for easy reinstallation

E. Raise vehicle and disconnect all items under the vehicle

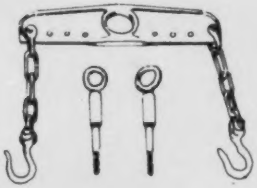
F. Keep bolts, clips, and brackets removed from under the vehicle in a separate, marked parts tray for easy reinstallation

G. Lower vehicle to the floor before removing the engine

Special Tools and Equipment

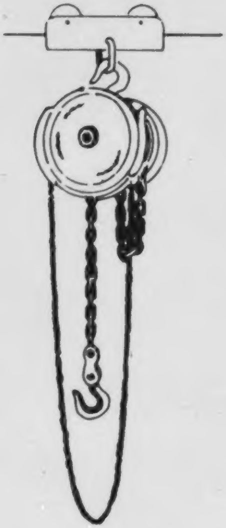


Carburetor

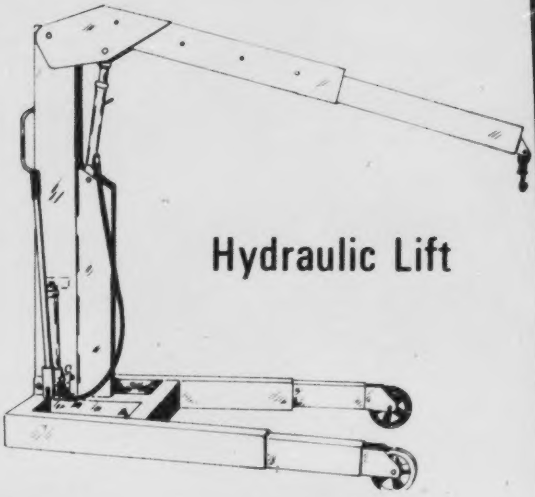


Cylinder Head Bolt

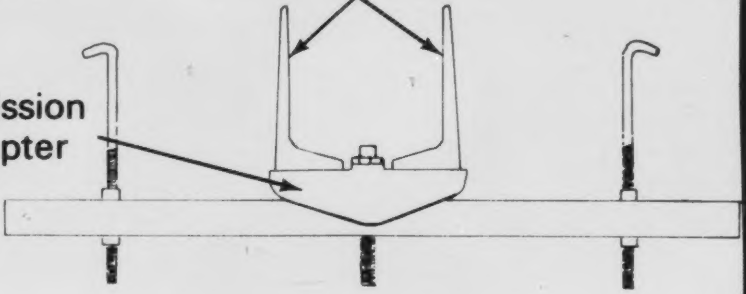
Engine Lift Adapters



Chain Hoist



Hydraulic Lift


Engine Adapters
Transmission Adapter

Engine or Transmission Support

ENGINE REMOVAL
UNIT II

JOB SHEET #1--REMOVE AN ENGINE WITH AN AUTOMATIC TRANSMISSION

I. Tools and equipment

   A. Hoist or lift suitable for lifting engine

   B. Engine pick-up adapter

   C. Engine chain

   D. Basic hand tool set

   E. Drain pan for coolant

   F. Drain pan for engine oil

   G. Appropriate transmission support

   H. Air conditioning manifold gauge set

   I. Penetrating oil

   J. Fender covers, 2

   K. Creeper

   L. Engine stand

   M. Parts trays

   N. Shop towels

   O. Safety glasses

   P. Oil filter wrench

   Q. Jack stands (4)

II. Procedure

(NOTE: This job sheet will cover the removal of an engine with standard equipment. Be aware of accessories and special equipment on a particular vehicle and plan the removal or disconnection of this equipment in your procedure of removal.)

   A. Remove battery and store in a dry, protected place

   (CAUTION: Disconnect ground cable first.)

JOB SHEET #1

B. Remove vehicle hood (Figure 1)

1. Scribe a mark around each hood hinge to indicate location for realignment

2. Position fender covers between fender and cowel areas and rear hood edges

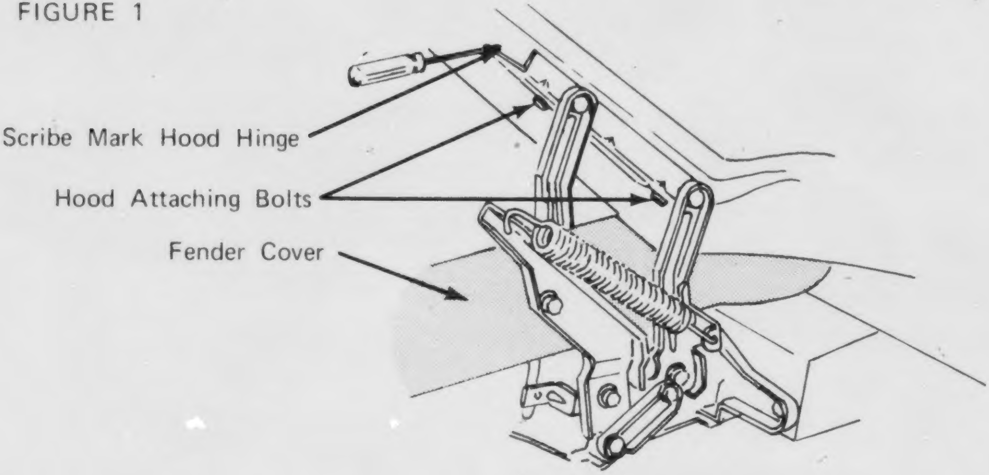
3. Prepare storage place for hood

   (NOTE: A good way to store the hood is to place a cover on top of the car and lay the hood on the cover, while being careful not to scratch the paint.)

4. Remove the hood with the aid of a helper

   (NOTE: Store the hood attaching bolts in their original positions.)

FIGURE 1



C. Drain the cooling system

1. Drain the radiator

2. Drain the cylinder block if possible

(NOTE: On V-engines there will be a drain plug on each side of the block.)

D. Drain engine oil

E. Remove oil filter

F. Remove air filter

JOB SHEET #1

G. Discharge air conditioning system (Figure 2)

(NOTE: See instructor for alternate procedures for various models and equipment.)

(CAUTION: A full face shield and safety glasses should be worn while working with air conditioning refrigerant.)

1. Remove service valve caps

2. Connect hose from high pressure gauge to discharge service valve

   (NOTE: This is the service valve on the line from compressor to condenser. Be sure the manifold valves on the gauge set are closed before connecting hoses on shrader type service valves.)

3. Connect hose from low pressure gauge to the compressor inlet service valve

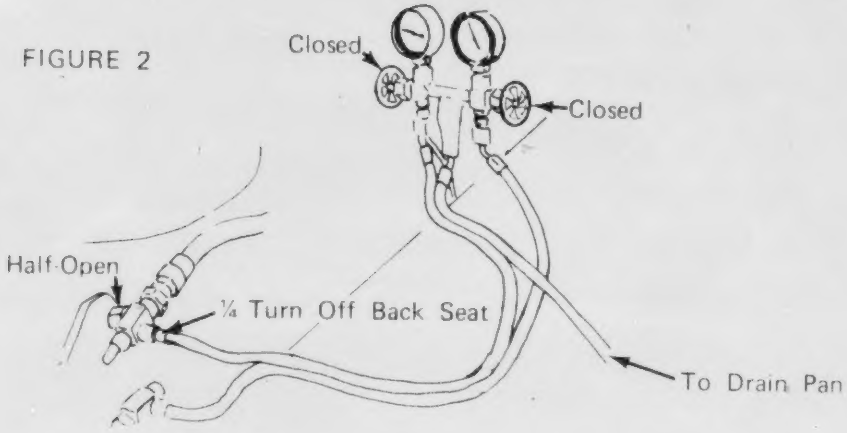
   (NOTE: This is the service valve in the line from compressor to evaporator.)

4. Place the free end of the gauge set service hose in a drain pan

5. Open both service valves on the compressor if they are of the manual type

6. Open both manifold valves very slowly until refrigerant is being expelled but little or no oil vapor is escaping from the hose

FIGURE 2



(NOTE: Manifold valves will have to be opened a little more several times as the pressure decreases.)

JOB SHEET #1

H. Remove the radiator (Figure 3)

1. Remove upper radiator hose
2. Remove lower radiator hose
3. Disconnect transmission cooling lines from radiator

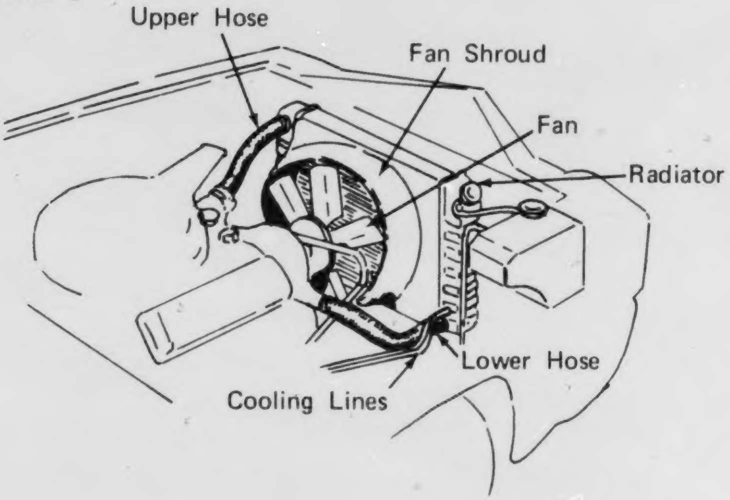
   (CAUTION: Use a backup tubing wrench on the line connections to prevent damage to radiator and cooling lines.)

4. Disconnect fan shroud from radiator
5. Remove any other accessories necessary to allow radiator removal
6. Remove radiator retaining bolts
7. Remove radiator from vehicle

   (CAUTION: Be careful not to damage core fins of the radiator.)

8. Remove heater hoses

FIGURE 3


Upper Hose
Fan Shroud
Fan
Radiator
Lower Hose
Cooling Lines

JOB SHEET #1

I. Disconnect all electrical wiring on top side of engine (Figure 4)

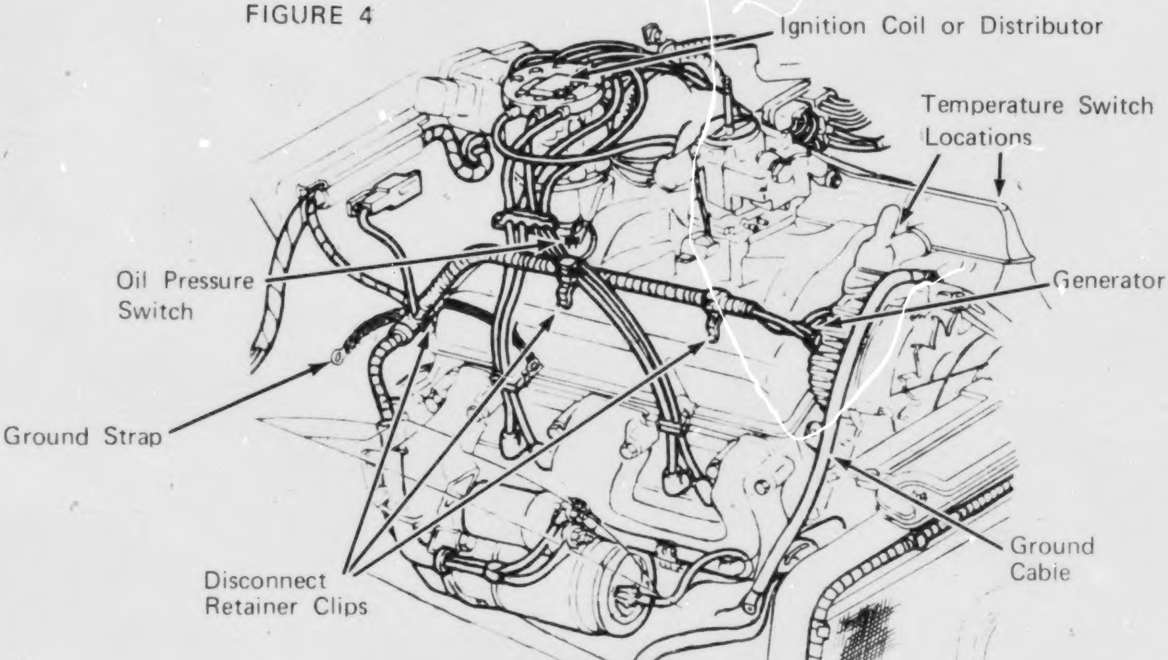
(NOTE: Label each wire's location on masking tape and stick tape on the wire or draw a wiring diagram.)

1. Disconnect ignition battery lead and tachometer lead
2. Disconnect charging system wiring on alternator
3. Disconnect temperature and oil pressure switch wires

   (NOTE: Some oil and temperature gauges will be connected to the engine with tubing which will have to be disconnected.)

4. Disconnect air conditioning clutch wire
5. Disconnect emission control wiring
6. Disconnect engine ground straps if accessible from engine compartment
7. Disconnect any other electrical wiring necessary for engine removal

FIGURE 4

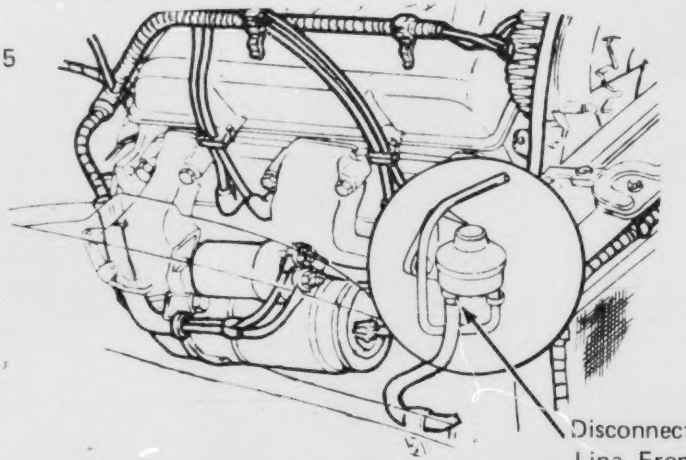

Ignition Coil or Distributor
Temperature Switch Locations
Oil Pressure Switch
Generator
Ground Strap
Ground Cable
Disconnect Retainer Clips

JOB SHEET #1

J. Disconnect fuel line between fuel pump and line going to fuel tank and plug line (Figure 5)

(CAUTION: Use backup tubing wrenches on fuel line connections to avoid damage to fittings or twisting the line.)

FIGURE 5

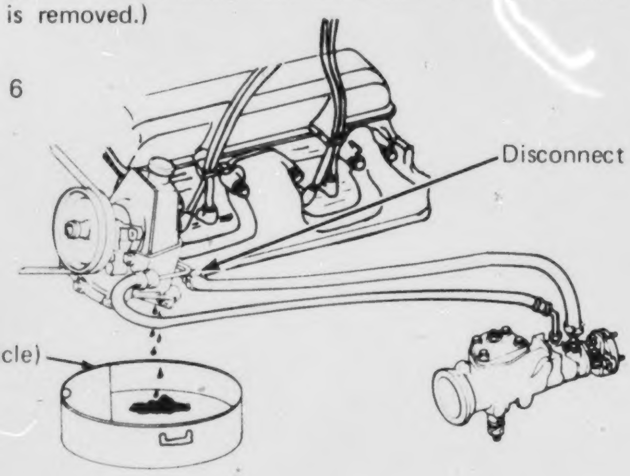

Disconnect Fuel
Line From Pump

K. Disconnect power steering pump (Figure 6)

1. Place oil drain pan on floor under power steering pump to catch fluid as hoses are disconnected
2. Disconnect power steering fluid hoses at pump
3. Plug hoses to prevent contaminants from getting in the power steering system
4. Store hoses on fender panel
5. Remove drain pan when pump has completely drained

   (NOTE: If possible, leave the pump on engine until the engine is removed.)

FIGURE 6


Disconnect Hoses
Drain Pan
(under vehicle)

JOB SHEET #1

L. Remove air conditioning gauge manifold set

M. Disconnect air conditioning hoses

(NOTE: Evaluate the hose routing and disconnect in the least amount of places that will allow engine removal.)

N. Plug all hose connections on air conditioning system that were disconnected

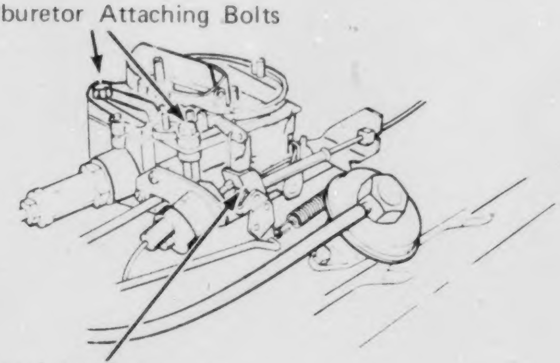
(NOTE: Use plastic plugs or duct tape to seal the air conditioning connections that were separated.)

O. Disconnect accelerator linkage to the carburetor (Figure 7)

(NOTE: If a carburetor lift adapter is to be used, remove the carburetor and install the lift adapter.)

(CAUTION: Inspect all carburetor bolts before installing the adapter.)

FIGURE 7



P. Disconnect vacuum lines to power brakes, fuel vapor cannister, automatic transmission, and heating and air conditioning system

(NOTE: It may be necessary to disconnect other vacuum hoses to additional systems.)

Q. Remove any fender braces or accessories necessary to provide ample clearance for engine removal

R. Install engine lift adapter if not already accomplished

(NOTE: At this point all work on top of the engine necessary for engine removal should be completed.)

JOB SHEET #1

S. Raise vehicle and secure on jack stand

(CAUTION: Use care not to let the hood slide off the top of the vehicle if it was stored there.)

T. Remove engine starter

(NOTE: Be sure to disconnect starter wiring or cable that may be connected to engine in wire hangers.)

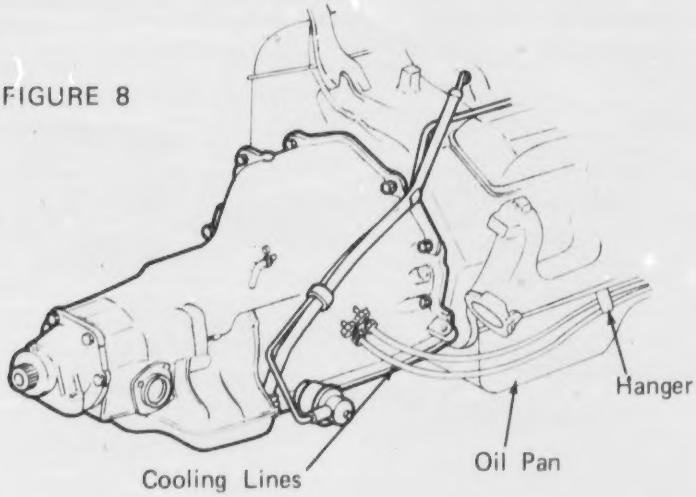
U. Disconnect automatic transmission from engine

(NOTE: Most automatic transmissions can be disconnected from the engine so the transmission will remain in the vehicle. If this procedure is questionable for your vehicle, consult the appropriate service manual.)

1. Remove transmission cooling lines from hangers attached to the engine (Figure 8)

   (NOTE: It may be helpful to tie the lines to the vehicle frame to keep them from being damaged.)

FIGURE 8



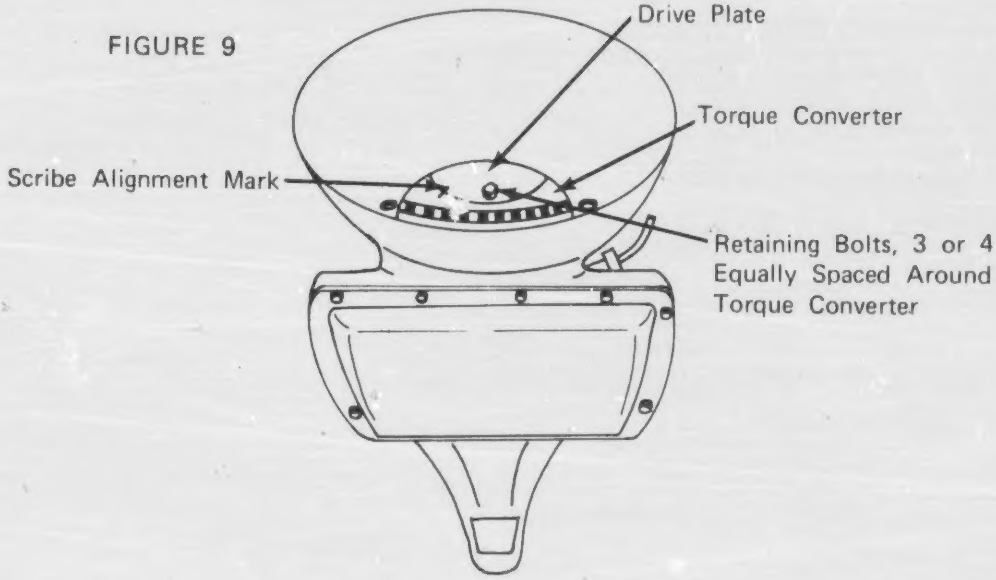
2. Remove torque converter splash pan or other covering necessary to obtain access to converter drive plate attaching bolts

3. Mark converter and drive plate to aid in reassembly

JOB SHEET #1

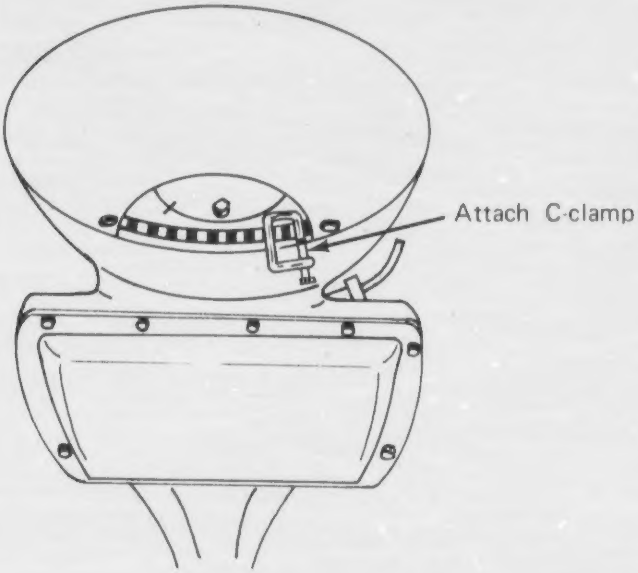
4. Remove converter drive plate bolts (Figure 9)

FIGURE 9


Drive Plate
Torque Converter
Scribe Alignment Mark
Retaining Bolts, 3 or 4 Equally Spaced Around Torque Converter

5. Attach a small C-clamp on lower front of transmission torque converter housing to insure that the converter remains in its proper position during engine removal (Figure 10)

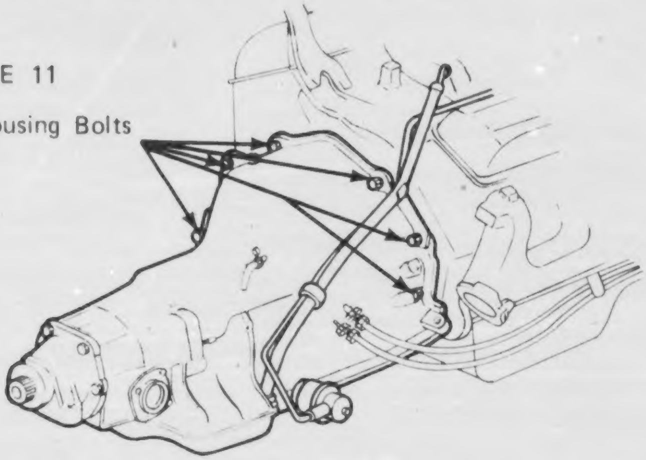
FIGURE 10


Attach C-clamp

JOB SHEET #1

6. Remove bell housing bolts (Figure 11)

FIGURE 11


Bell Housing Bolts

7. Remove any bolts attaching transmission filler tube, vacuum lines, or wiring to engine

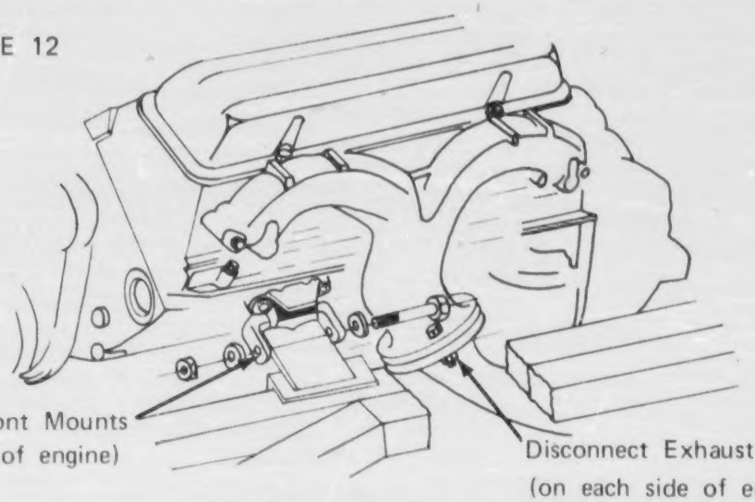
8. Support the front of the transmission in its normal position relative to vehicle

(NOTE: A frame-mounted support will be best.)

V. Disconnect exhaust pipe at manifold (Figure 12)

W. Disconnect front motor mounts (Figure 12)

FIGURE 12

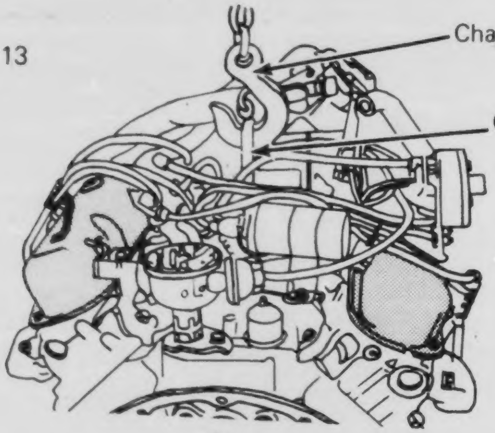

Disconnect Front Mounts
(on each side of engine)
Disconnect Exhaust Pipe
(on each side of engine
on V-models)

JOB SHEET #1

X. Lower vehicle to the floor

Y. Attach chain hoist or appropriate lifting equipment to lift adapter (Figure 13)

FIGURE 13

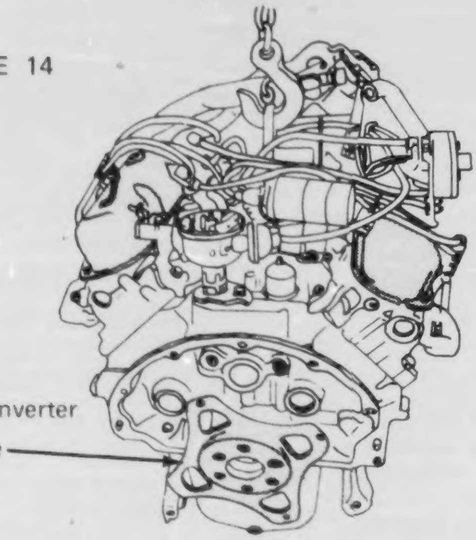

Chain Hoist
Carburetor Lift Adapter

Z. Lift engine slowly out of engine compartment while maneuvering engine to keep it from binding on motor mounts, transmission, or other accessories; watch for any item overlooked while disconnecting the engine

(NOTE: Be sure to pry the torque converter away from the crankshaft as the engine is moved forward.)

AA. Remove torque converter drive plate from crankshaft (Figure 14)

FIGURE 14


Torque Converter
Drive Plate

JOB SHEET #1

BB. Install engine on repair stand (Figure 15)

1. Select spacers that go between the engine stand adjustable arms and engine that will provide enough clearance to remove the crankshaft from the engine

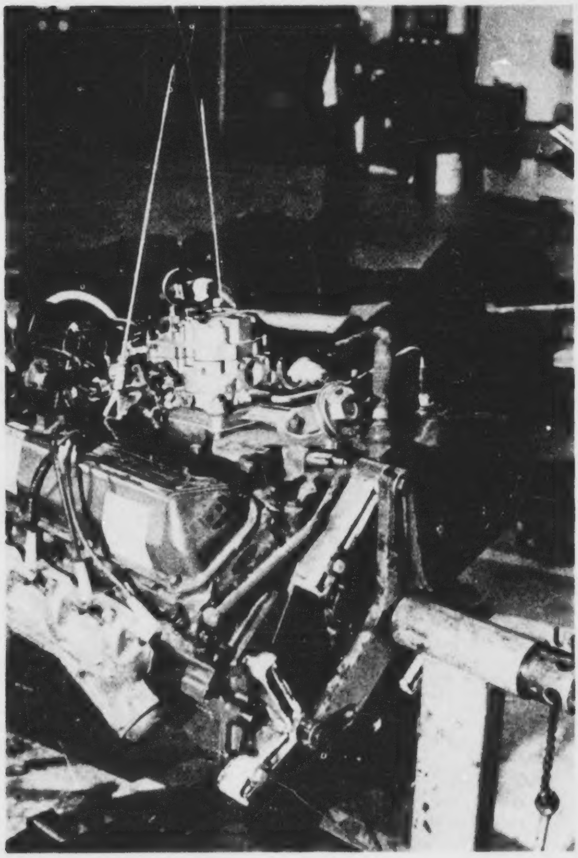
2. Select bolts that are in good condition and are approximately one inch (25.4 mm) longer than the thickness of the adjustable arms and spacers

3. Attach the arms and spacers to the engine block at the transmission attaching bolt holes

   (NOTE: The engine should be supported on four adjustable arms spaced as evenly around the back of the engine as possible. The center line of the engine should be located at the center of the shaft on which the engine will pivot.)

4. Tighten all attaching bolts on the adjustable arms and engine stand securely

FIGURE 15



ENGINE REMOVAL
UNIT II

JOB SHEET #2--REMOVE ENGINE WITH STANDARD TRANSMISSION

I. Tools and equipment

   A. Hoist or suitable engine lift

   B. Engine pick-up adapter

   C. Engine chain

   D. Basic hand tool set

   E. Drain pan for coolant

   F. Drain pan for oil

   G. Air conditioning manifold gauge set

   H. Penetrating oil

   I. Fender covers, 2

   J. Creeper

   K. Engine stand

   L. Parts trays

   M. Safety glasses

   N. Oil filter wrench

   O. Extra U-joint yoke (that fits transmission in vehicle)

   P. Transmission jack

   Q. Appropriate rear engine support

II. Procedure

(NOTE: This job sheet will cover the removal of an engine with standard equipment. Be aware of accessories and special equipment on a particular vehicle and plan the removal or disconnection of this equipment in your procedure of removal.)

   A. Remove battery and store in a dry, protected place

   (CAUTION: Disconnect the ground cable first.)

JOB SHEET #2

B. Remove vehicle hood (Figure 1)

1. Scribe a mark around each hood hinge to indicate location for realignment

2. Position fender cover between fender and cowel area and rear hood edge

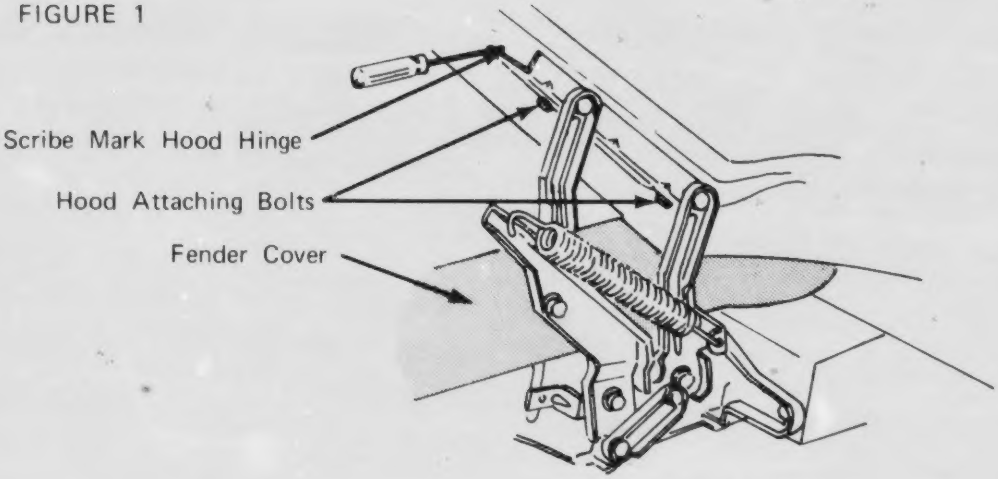
3. Prepare storage place for hood

   (NOTE: A good way to store the hood is to place a cover on top of the car and lay the hood on the cover, while being careful not to scratch the paint.)

4. Remove the hood with the aid of a helper

   (NOTE: Remove the hood attaching bolts in their original positions.)

FIGURE 1



C. Drain the cooling system

1. Drain the radiator

2. Drain the cylinder block

   (NOTE: On V-engines there will be a drain plug on each side of the block.)

D. Drain engine oil

E. Remove oil filter

JOB SHEET #2

F. Remove air filter

G. Discharge air conditioning system (Figure 2)

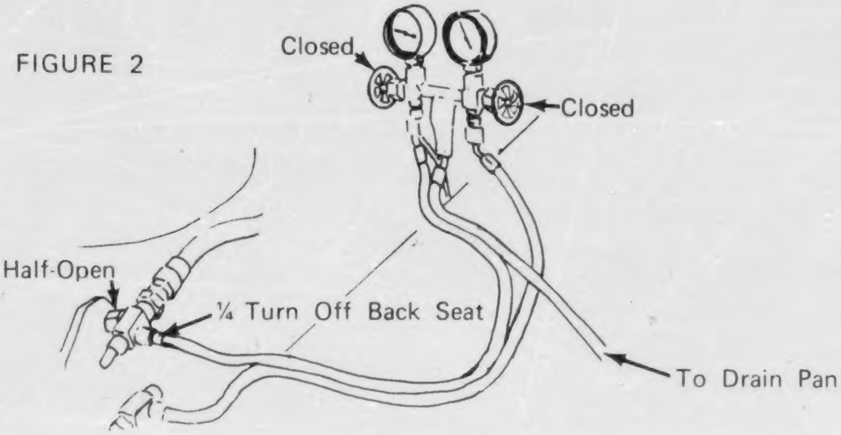
(NOTE: See instructor for alternate procedure on different vehicle models and various types of equipment.)

(CAUTION: A full face shield and safety glasses should be worn while working with air conditioning refrigerants.)

1. Remove service valve caps
2. Connect hose from high pressure gauge to discharge service valve

   (NOTE: This is the service valve in the line from compressor to the condenser. Be sure the manifold valves on the gauge set are closed before connecting hoses on shrader type service valves.)
3. Connect hoses from low pressure gauge to the compressor inlet service valve
4. Place the free end of the gauge set service hose in a drain pan
5. Open both service valves on the compressor if they are of the manual type
6. Open both manifold valves very slowly until refrigerant is being expelled but little or no oil vapor is escaping from the hose

FIGURE 2



(NOTE: The manifold valves will have to be opened a little more several times as the pressure decreases.)

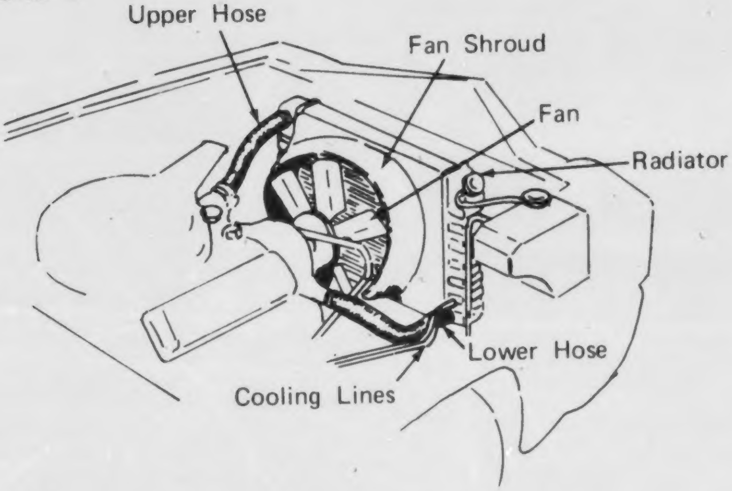
JOB SHEET #2

H. Remove the radiator (Figure 3)

1. Remove upper radiator hose
2. Remove lower radiator hose
3. Disconnect fan shroud from radiator
4. Remove any other accessories necessary to allow radiator removal
5. Remove radiator retaining bolts
6. Remove radiator from vehicle

   (CAUTION: Be careful not to damage core fins of the radiator.)
7. Remove heater hoses

FIGURE 3



I. Disconnect all electrical wiring on top side of engine (Figure 4)

(NOTE: Label each wire's location on masking tape and tag the wire.)

1. Disconnect ignition battery lead and tachometer lead
2. Disconnect charging system wiring (alternator)

JOB SHEET #2

3. Disconnect temperature and oil pressure switch wires

   (NOTE: Some oil and temperature gauges will be connected to the engine with tubing which will have to be disconnected.)

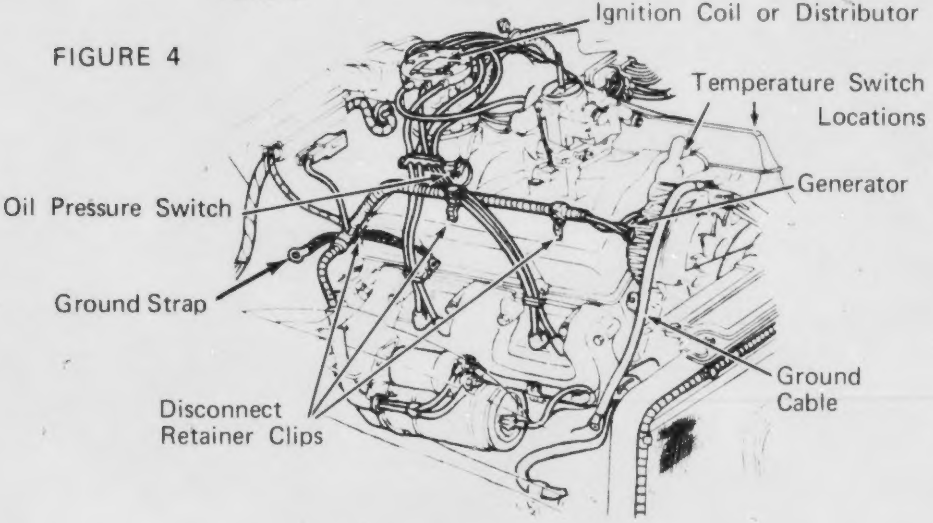
4. Disconnect air conditioning clutch wire

5. Disconnect emission control wiring

6. Disconnect engine ground straps if accessible from engine compartment

7. Disconnect any other electrical wiring necessary for engine removal

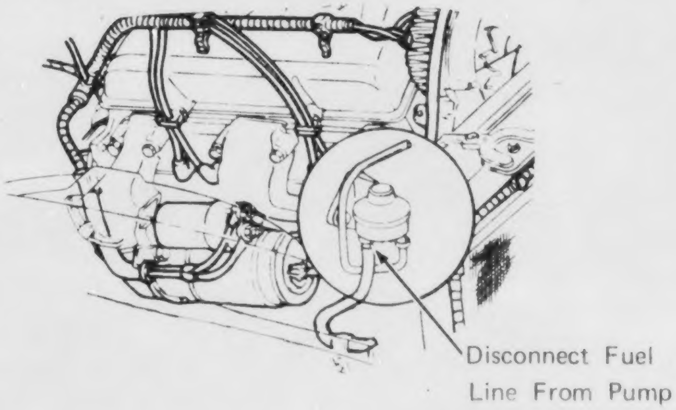
FIGURE 4


Ignition Coil or Distributor
Temperature Switch Locations
Generator
Oil Pressure Switch
Ground Strap
Ground Cable
Disconnect Retainer Clips

J. Disconnect fuel line between fuel pump and line going to fuel tank and plug line (Figure 5)

   (CAUTION: Use backup tubing wrenches on fuel line connections to avoid damage to fittings or twisting the line.)

FIGURE 5


Disconnect Fuel Line From Pump

JOB SHEET #2

K. Disconnect power steering pump (Figure 6)

   1. Place oil drain pan on floor under power steering pump to catch fluid as hoses are disconnected

   2. Disconnect power steering fluid hoses at pump

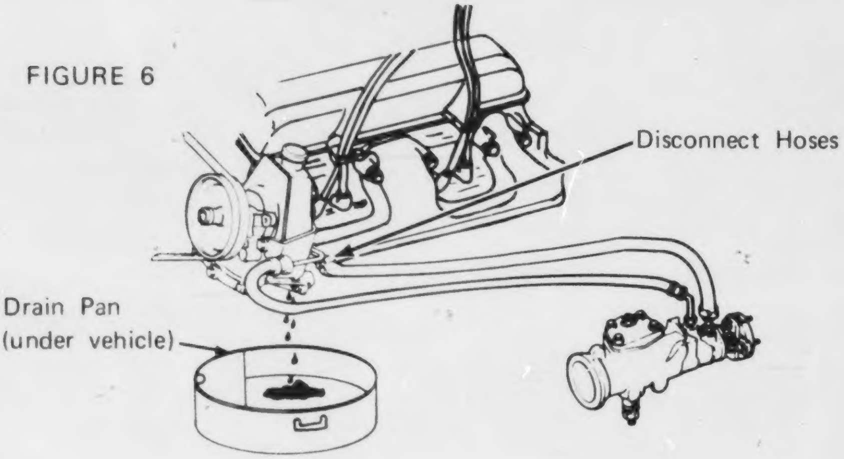
   3. Plug hoses to prevent contaminants from getting in the power steering system

   4. Store hoses on fender panel

   5. Remove drain pan when pump has completely drained

   (NOTE: If possible, leave the pump on the vehicle until the engine is removed.)

FIGURE 6



L. Remove air conditioning gauge manifold set

M. Disconnect air conditioning hoses

(NOTE: Evaluate the hose routing and disconnect in the least amount of places that will allow engine removal.)

N. Plug all hose connections on air conditioning system that were disconnected

(NOTE: Use plastic plugs or duct tape to seal the air conditioning connections that were separated.)

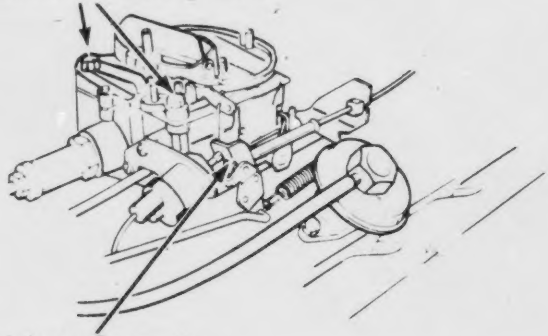
O. Disconnect accelerator linkage to the carburetor (Figure 7)

(NOTE: If a carburetor lift adapter is to be used, remove the carburetor and install the lift adapter.)

(CAUTION: Inspect all carburetor bolts before installing the adapter.)

JOB SHEET #2

FIGURE 7



P. Disconnect vacuum line to power brakes, fuel vapor cannister, automatic transmission, and heating and air conditioning system

(NOTE: It may be necessary to disconnect other vacuum hoses to additional systems.)

Q. Remove any fender braces or accessories necessary to provide ample clearance for engine removal

R. Install engine lift adapter if not already accomplished

(NOTE: At this point all work on top of the engine necessary for engine removal should be completed.)

S. Raise vehicle and secure on jack stands

(CAUTION: Use care not to let the hood slide off of the top of the vehicle as it is being raised.)

T. Remove engine starter

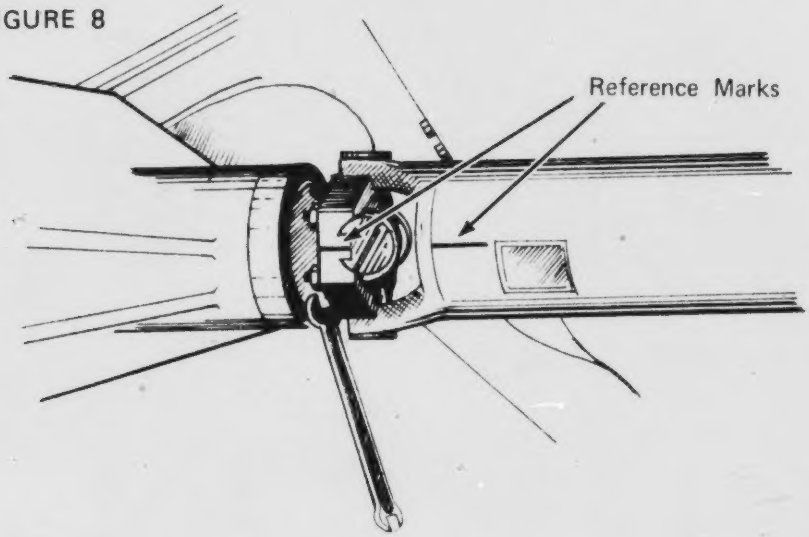
(NOTE: Be sure to disconnect starter wiring or cable that may be connected to the engine in wire hangers.)

U. Remove standard transmission from vehicle

1. Mark drive shaft rear flange and pinion flange for reassembly (Figure 8)
2. Disconnect drive shaft from pinion flange

JOB SHEET #2

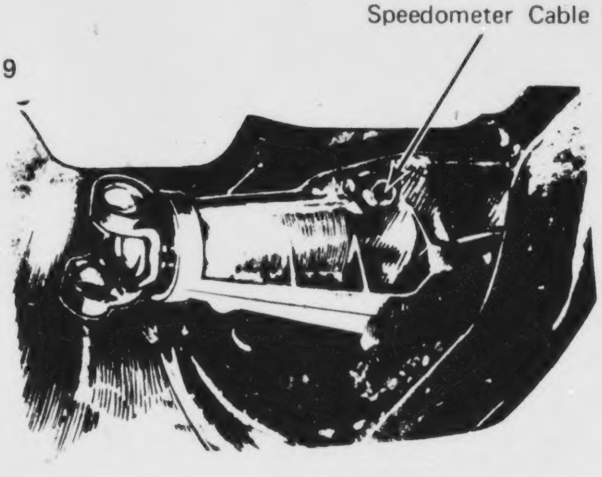
FIGURE 8


Reference Marks

3. Remove drive shaft center support bolts if so equipped

4. Slide drive shaft front slip joint out of transmission tail housing and immediately insert extra slip joint into transmission to prevent lubrication oil from draining (Figure 9)

FIGURE 9


Speedometer Cable Connection

5. Disconnect speedometer drive cable

JOB SHEET #2

6. Disconnect the shift linkage

   (NOTE: On floor shift models, usually it will be necessary to remove the shift mechanism also to allow removal of the transmission.)

7. Disconnect any electrical wiring attached to the transmission

8. Disconnect transmission rear mount either at the crossmember or transmission tail housing

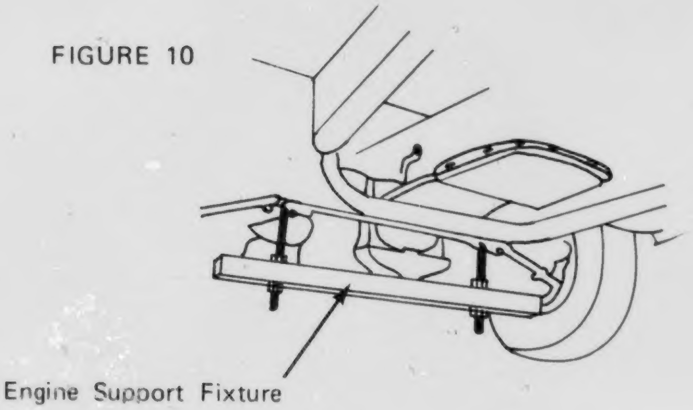
9. Raise the transmission off the crossmember slightly

   (NOTE: A transmission jack should be used to remove the transmission.)

10. Remove the crossmember from the vehicle

11. Install rear engine support (Figure 10)

FIGURE 10



(NOTE: A frame-mounted support will be easier to use.)

12. Lower the transmission until the engine rests on the support

13. Remove bolts securing transmission to the clutch housing

    (NOTE: On some models the clutch housing is an integral part of the transmission case and will be separated at the engine.)

14. Adjust the jack under the transmission to support the transmission's weight

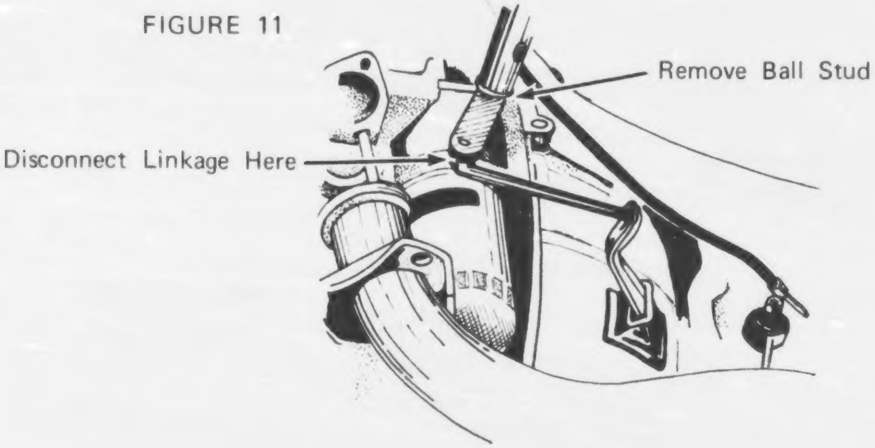
JOB SHEET #2

15. Pull transmission away from clutch housing and lower to the floor

16. Disconnect clutch linkage as close to clutch housing as possible

17. Disconnect clutch cross shaft from engine or clutch housing as required (Figure 11)

FIGURE 11

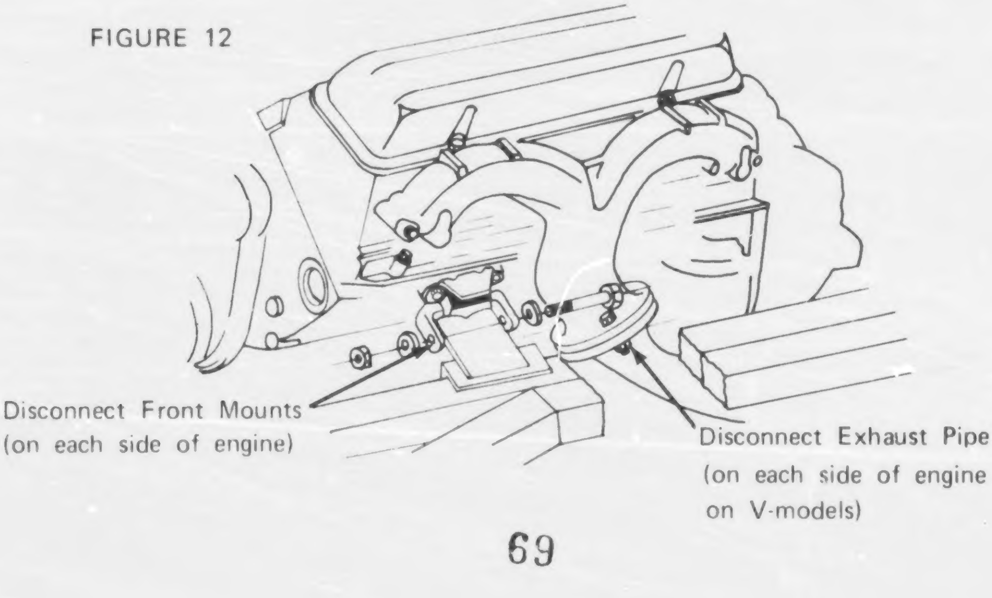

Remove Ball Stud
Disconnect Linkage Here

18. Disconnect hydraulic line from slave cylinder on hydraulic clutch models

V. Disconnect front motor mounts (Figure 12)

(NOTE: Most mounts can be disconnected so that they will still support the weight of the engine but will allow engine to be lifted free.)

FIGURE 12


Disconnect Front Mounts (on each side of engine)
Disconnect Exhaust Pipe (on each side of engine on V-models)

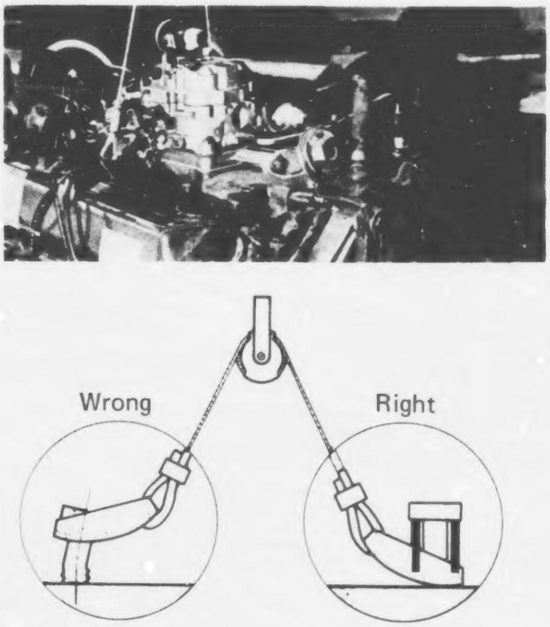
JOB SHEET #2

W. Disconnect exhaust pipe at manifold

X. Lower vehicle to the floor

Y. Attach chain hoist or appropriate lifting equipment to lift adapter (Figure 13)

FIGURE 13



Z. Lift engine slowly out of the engine compartment while maneuvering engine to prevent binding on motor mounts or other accessories

(NOTE: Watch for any item overlooked while disconnecting the engine.)

AA. Lower engine to the floor as soon as engine is clear of the vehicle

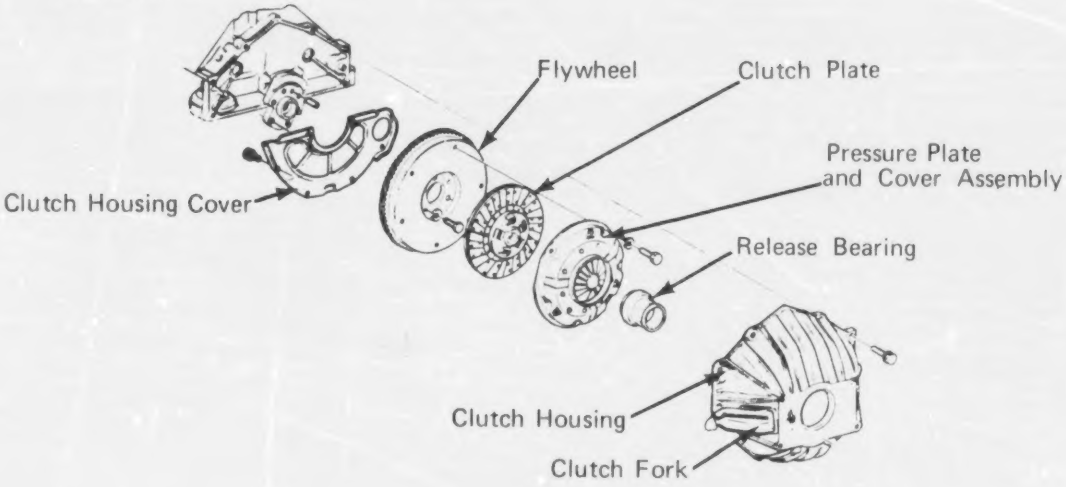
BB. Remove the clutch housing (Figure 14)

CC. Remove the clutch and pressure plate from the flywheel (Figure 14)

JOB SHEET #2

DD. Remove the flywheel (Figure 14)

FIGURE 14


Flywheel
Clutch Plate
Pressure Plate and Cover Assembly
Clutch Housing Cover
Release Bearing
Clutch Housing
Clutch Fork

EE. Raise the engine

FF. Install engine in repair stand (Figure 15)

1. Select spacers that go between the engine stand adjustable arms and engine that will provide enough clearance to remove the crankshaft from the engine

2. Select bolts that are in good condition and are approximately one inch (25.4 mm) longer than the thickness of the adjustable arms and the spacers selected

   (CAUTION: It is very important that the bolts are not too long and bottom out in the hole before they tighten the arms, or that they are not too short and will not catch enough threads in the block to support the weight of the engine.)

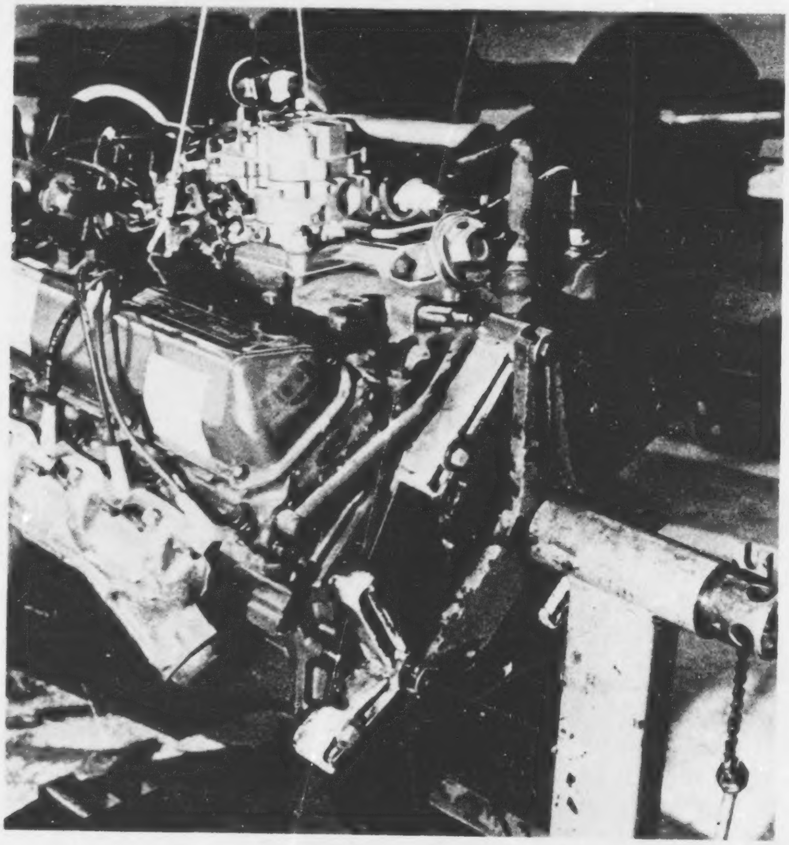
3. Attach the arms and spacers to the engine block at the clutch housing attaching bolt holes

   (NOTE: The engine should be supported on four adjustable arms spaced as evenly around the back of the engine as possible. The center line of the engine should be located at the center of the shaft on which the engine will pivot.)

JOB SHEET #2

4. Tighten all attaching bolts on the adjustable arms and engine stand securely (Figure 15)

FIGURE 15



ENGINE REMOVAL
UNIT II

TEST

NAME ______________________ SCORE ______________

1. Match the terms on the right to the correct definitions.

_____a. Metal partition between the driver's compartment and engine compartment

_____b. That part of the car body between the engine firewall and the front of the dash panel

_____c. Metal covering around the flywheel and clutch or the torque converter assembly

_____d. Sheet metal liner in the front fender that separates the front wheel compartment from the engine compartment

_____e. Metal yoke between the front fenders that supports the front of the fender, radiator, and air conditioning condenser

_____f. Component of the air conditioning system mounted in front of the radiator on the radiator support

_____g. Component of an air conditioning system which is mounted on the firewall of the vehicle

_____h. Spring-loaded valve similar to a tire valve located inside the service fitting of an air conditioning system

_____i. Mobile fixture on which an engine can be mounted that allows the rotation of the engine to various positions to make repair work easier

1. Bell housing
2. Firewall
3. Cowel
4. Splash shield or apron
5. Air conditioning evaporator
6. Radiator support
7. Air conditioning condenser
8. Engine repair stand
9. Schrader valve

2. Select from the following list safety precautions to observe while removing the engine. Place an "X" in the correct blanks.

______a. Do not work on an engine that is supported only by a hoist

______b. Do not work under vehicle while lifting the engine on a hoist

______c. Remove fender covers while lifting the engine to avoid getting anti-freeze on them

______d. Check all equipment connections before lifting engine

______e. Be sure floor will provide adequate work room and is clean and free of obstacles that would interfere with hoist or engine movement

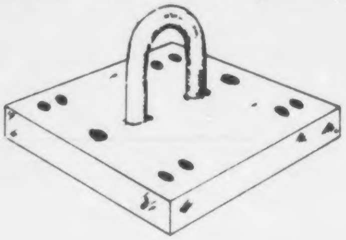
______f. Do not raise engine higher than necessary to clear vehicle

______g. Use caution to prevent brake fluid from coming in contact with vehicle paint

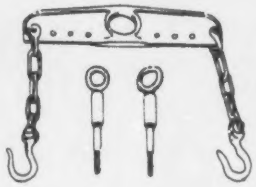
______h. Wash the floor immediately before engine removal to settle any dust that might get on the engine

______i. Determine if the hoist capacity is sufficient to handle the engine weight

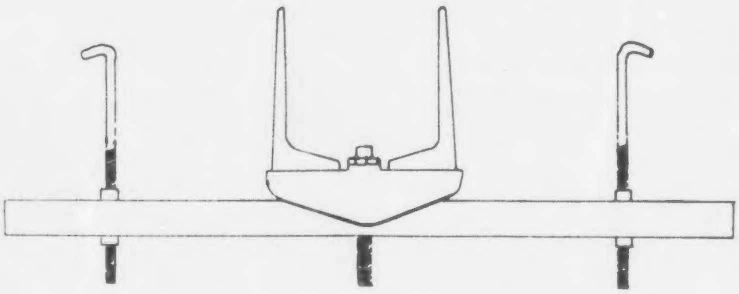
3. Identify the following tools and equipment used in engine removal by writing the correct names in the spaces provided.



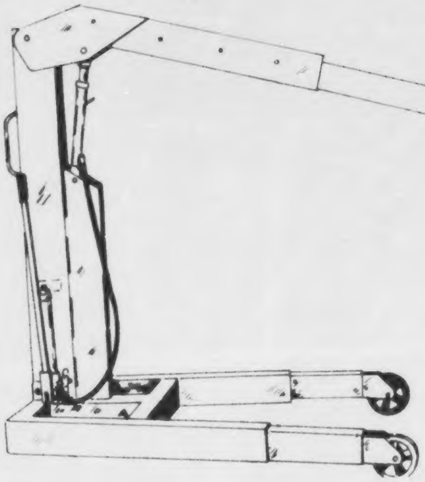
a. ______________________________

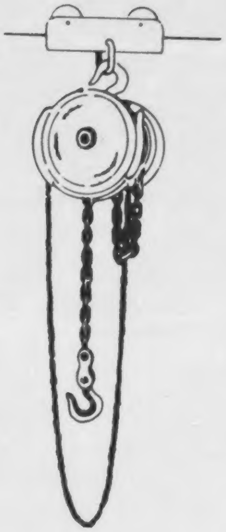


b. ______________________________



c. ______________________________





d. ______________________ e. ______________________

4. Arrange in order the procedure for planning engine removal. Place a "1" before the first step, a "2" before the second step, and so on.

_____a. Keep bolts, clips, and brackets removed from each side of the engine compartment in separate, marked parts trays for easy reinstallation

_____b. Provide ample room for work around vehicle to include the type of hoist used

_____c. Raise vehicle and disconnect all items under the vehicle

_____d. Remove or disconnect all items possible by working over the fender

_____e. Keep bolts, clips, and brackets removed from under the vehicle in a separate, marked parts tray for easy reinstallation

_____f. Prepare storage for radiator, hood, and other items removed during engine removal

_____g. Lower vehicle to the floor before removing the engine

5. Demonstrate the ability to:

a. Remove an engine with an automatic transmission.

b. Remove an engine with a standard transmission.

(NOTE: If these activities have not been accomplished prior to the test, ask the instructor when the above activities should be completed.)

ENGINE REMOVAL
UNIT II

ANSWERS TO TEST

1. a. 2
   b. 3
   c. 1
   d. 4
   e. 6
   f. 7
   g. 5
   h. 9
   i. 8

2. a, b, d, e, f, i

3. a. Carburetor engine lift adapter
   b. Cylinder head bolt engine lift adapter
   c. Engine or transmission support
   d. Hydraulic lift
   e. Chain hoist

4. a. 4
   b. 2
   c. 5
   d. 3
   e. 6
   f. 1
   g. 7

5. Performance skills evaluated to the satisfaction of the instructor

ENGINE DISASSEMBLY
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to prepare the work area and disassemble an engine while visually inspecting each component for damage. This knowledge will be evidenced through demonstration and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with engine disassembly and inspection to their correct definitions.
2. List safety precautions to observe during engine disassembly.
3. Select from a list factors to consider when preparing to disassemble an engine.
4. Select from a list items to inspect during engine disassembly.
5. Demonstrate the ability to:
    a. Clean outside of engine.
    b. Disassemble an engine.

ENGINE DISASSEMBLY
UNIT III

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Secure materials and equipment for job sheet demonstrations.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss procedures outlined on the job sheets.

   G. Evaluate student performance of job sheets.

   H. Give test.

II. Unit references:

   A. Ellinger, Herbert E. *Automechanics.* Englewood Cliffs, New Jersey: Prentice-Hall Inc., 1972.

   B. Crouse, William H. *Automotive Engine Design.* New York. McGraw-Hill Book Co., 1970.

   C. Crouse, William H. *Automotive Mechanics.* 7th ed. New York: McGraw-Hill Book Co., 1975.

   D. *Chevrolet Service Manual.* Detroit. Chevrolet Motor Div./General Motors Corp., 1977.

   E. *Chrysler, Plymouth, Dodge Chassis Service Manual.* Detroit: Chrysler Corp., 1976.

   F. *Ford Service Manual.* Dearborn, Michigan: Ford Motor Co., 1975-76.

ENGINE DISASSEMBLY
UNIT III

INFORMATION SHEET

I. Terms and definitions

   A. Engine repair stand--Strong stand suitable for supporting a complete engine in a variety of positions convenient for engine repair

   B. Steam cleaner--Device used to heat water to steam and to mix the steam with a detergent that will clean heavy oil and dirt buildup

   C. Engine subassemblies--Complete components of an engine, such as the cylinder head, intake manifold, or water pump

   D. Engine disassembly and inspection--Systematic method of removing parts and subassemblies in a particular sequence while looking for worn or damaged parts

II. Safety precautions to observe during engine disassembly

   A. Keep floor of work area clean and dry at all times

   B. Secure help when handling heavy engine components

   C. Make sure engine is securely attached to engine repair stand

   (NOTE: Bolts should be of the proper size and length for good engine support.)

   D. Center the weight on center of pivot of repair stand

   E. Keep tools and work bench clean and orderly

III. Factors to consider when preparing to disassemble an engine

   A. Clean outside of engine as much as possible

   B. Provide a clean, safe place for storage of parts and subassemblies

   C. Provide storage trays for bolts, clips, springs, and other subassemblies

   (NOTE: It will make reassembly faster and easier if a tray or compartment of a tray is available for each subassembly removed from the engine so that each group of fasteners can be separated.)

   D. Keep all special braces, spacers, and special bolts with the subassembly to which they belong

   Examples: Braces, bolts, and belts for power steering pump and air conditioner compressor

   E. Make a sketch of the accessories that may be difficult to reinstall

INFORMATION SHEET

IV. Items to inspect during engine disassembly

A. Cylinder head gaskets

B. Cylinder head for visible cracks

C. Valve train for broken parts

D. Valve for burned condition

E. Cylinder block water jacket for sludge buildup

F. Cylinder block expansion plugs

G. Cylinder block for visible cracks

H. Crankshaft journals

I. Crankshaft bearings

J. General condition of camshaft

K. General condition of all bolt hole threads

L. General condition of all observable parts

(NOTE: Your instructor may add more items to this list as necessary.)

ENGINE DISASSEMBLY
UNIT III

JOB SHEET #1--CLEAN OUTSIDE OF ENGINE

I. Tools and equipment

A. Steam cleaner or car wash machine

B. Wire brush

C. Carbon scraper

D. Duct tape or suitable replacement

E. Engine degreaser or suitable replacement

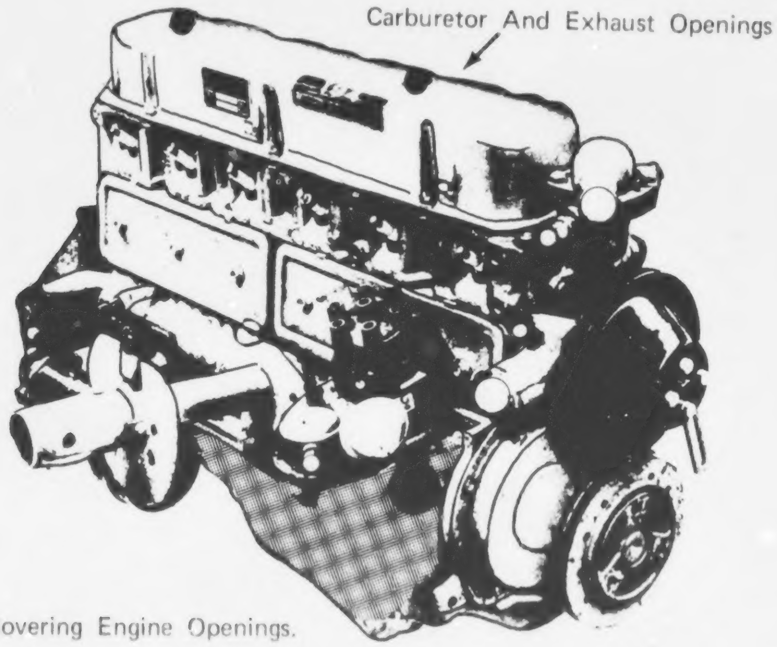
F. Rubber apron, gloves, and overshoes

G. Safety glasses and full face shield

II. Procedure

A. Seal all engine and accessory openings with duct tape or suitable replacement

(NOTE: This is to prevent moisture and other contaminants from entering the system and causing damage such as rust corrosion or scoring from abrasive. See Figure 1.)



○ ● = Tape Covering Engine Openings.

JOB SHEET #1

B. Remove and label all drive belts

C. Remove any electrical wiring and accessories, such as alternator and starter, that remain on the engine

D. Scrape heavily coated dirt from engine with carbon scraper

(NOTE: Cleaning should be done in a specially designated area that will provide for easy clean-up after job is completed.)

E. Soak all engine areas with degreaser

(CAUTION: Do not let cleaning chemicals get inside alternator or starter because this may remove insulation from the windings.)

F. Allow the engine to soak for at least thirty minutes

G. Clean the engine with a steam cleaner or other high pressure hot water source

(CAUTION: A rubber apron, gloves, and overshoes should be worn to protect clothing. A safety shield should be worn to protect the face.)

H. Scrape loose any stubborn dirt

I. Clean stubborn areas again with steam

J. Rinse engine with water

K. Move engine back to work area when it has dried sufficiently

L. Remove duct tape and prepare for disassembly

ENGINE DISASSEMBLY
UNIT III

JOB SHEET #2--DISASSEMBLE ENGINE

I. Tools and equipment

  A. Basic hand tool set

  B. Puller (vibration damper)

  C. Impact wrench

  D. Impact socket set

  E. Safety glasses

  F. Dial indicator

II. Procedure

(NOTE: While disassembling the engine, the technician should observe the conditions and look for problems with each item as it is removed. Some measurements and tests will be made during disassembly that will help the evaluation of the total engine.)

  A. Remove engine accessories (Figure 1)

    1. Secure engine in an upright position on the repair stand

    2. Remove air conditioning compressor

    (NOTE: All brackets and braces should be kept with the compressor and special bolts noted to aid reassembly. A separate parts tray should be used for storage of bolts and clips for engine accessories.)

    3. Remove power steering pump, if so equipped

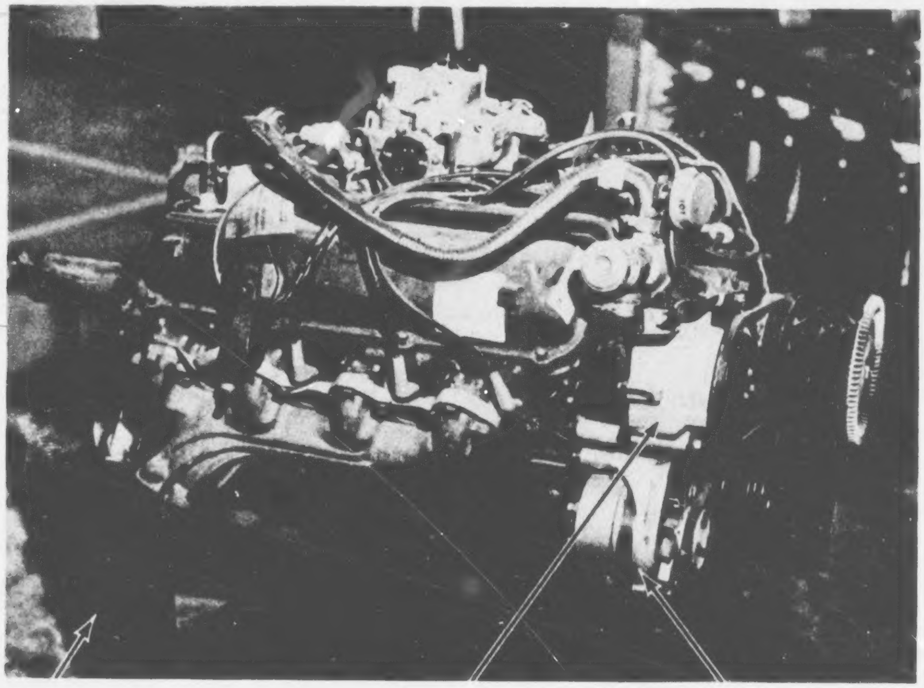
    4. Remove air pump and brackets, if so equipped

JOB SHEET #2

5. Remove alternator and brackets, if so equipped

(NOTE: Store these components away for engine reassembly.)

FIGURE 1



B. Remove engine exterior components (Figure 2)

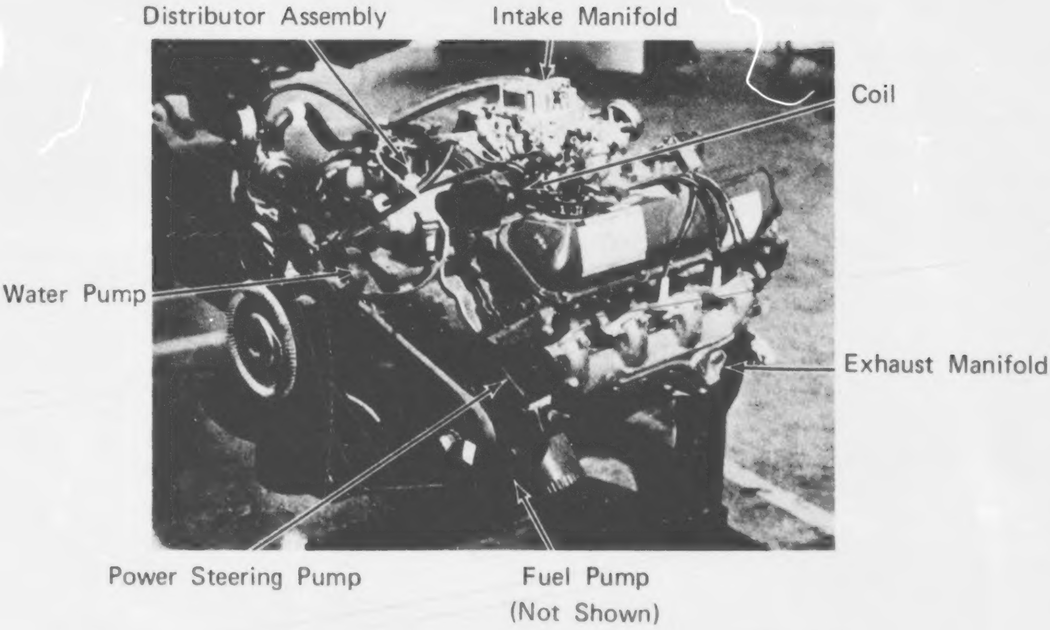
1. Remove ignition distributor and coil
2. Remove water pump
3. Remove fuel pump
4. Remove exhaust manifolds

(NOTE: On most in-line engines, the intake and exhaust manifolds will be removed as one unit.)

JOB SHEET #2

5. Remove intake manifold

FIGURE 2


Distributor Assembly
Intake Manifold
Coil
Water Pump
Exhaust Manifold
Power Steering Pump
Fuel Pump
(Not Shown)

6. Remove torsional vibration damper and drive pulley assembly (Figure 3)

   a. Remove retaining bolt or nut, if so equipped

   b. Remove drive pulleys from damper hub if necessary

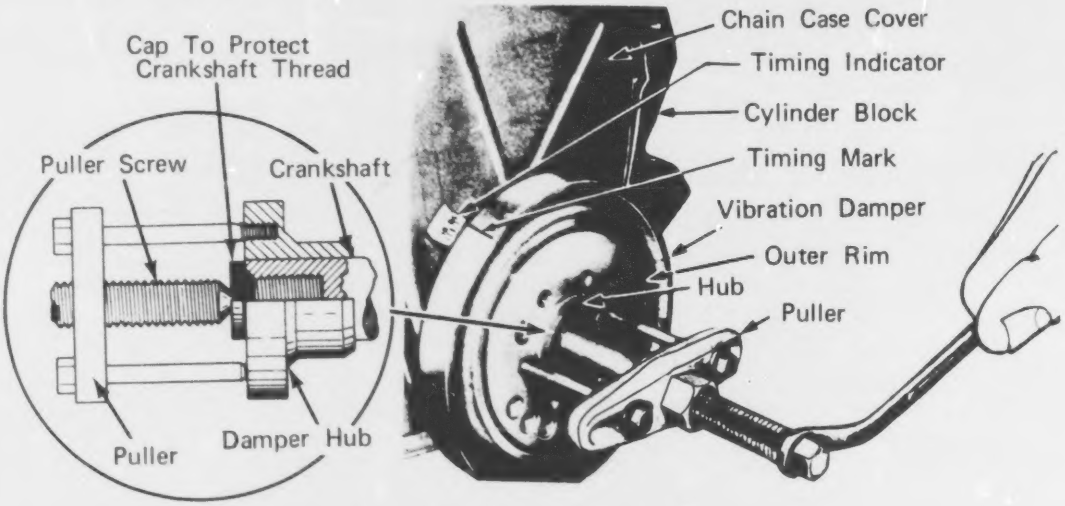
   c. Attach appropriate puller to damper hub

JOB SHEET #2

d. Pull damper hub

(CAUTION: Be sure the correct puller is used and that the threads in the end of the crankshaft are protected from the puller center bolt.)

FIGURE 3


Cap To Protect Crankshaft Thread
Puller Screw
Crankshaft
Puller
Damper Hub
Chain Case Cover
Timing Indicator
Cylinder Block
Timing Mark
Vibration Damper
Outer Rim
Hub
Puller

C. Remove cylinder heads (Figure 4)

(NOTE: On overhead camshaft models, refer to manufacturer's service manual for removal procedures.)

1. Remove valley chamber cover on V-models, and lifter side covers on in-line engines, if so equipped.)
2. Remove rocker arm cover(s)
3. Remove rocker arms as necessary for cylinder head removal
4. Remove push rods and store in sequence

   (NOTE: If push rods are stored in sequence, they can be replaced in their original position later.)

5. Remove any braces or accessories on the cylinder head not already removed
6. Remove cylinder head bolts

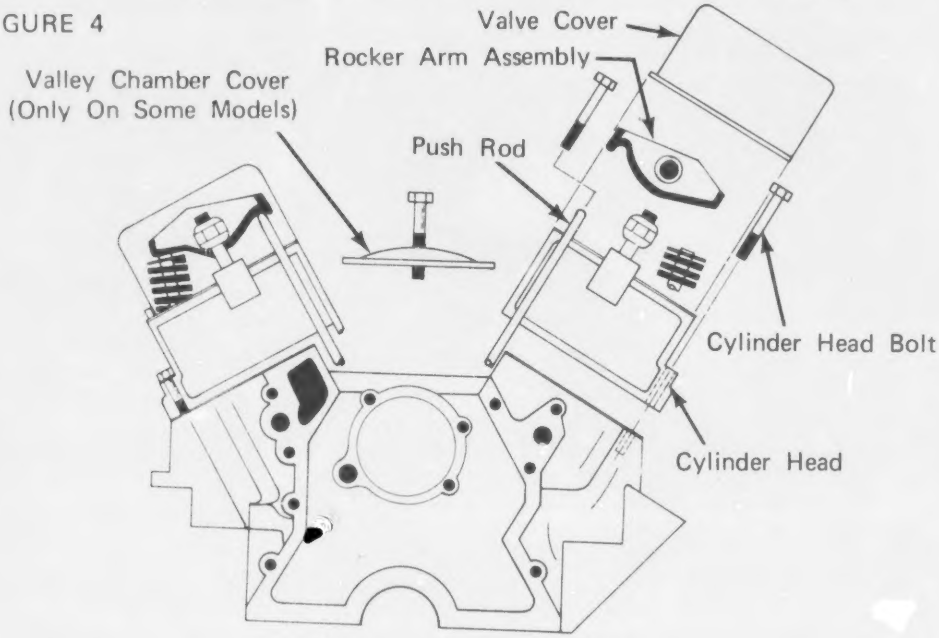
   (NOTE: Remove bolts on one cylinder head at a time on V-model engines.)

JOB SHEET #2

7. Remove cylinder head

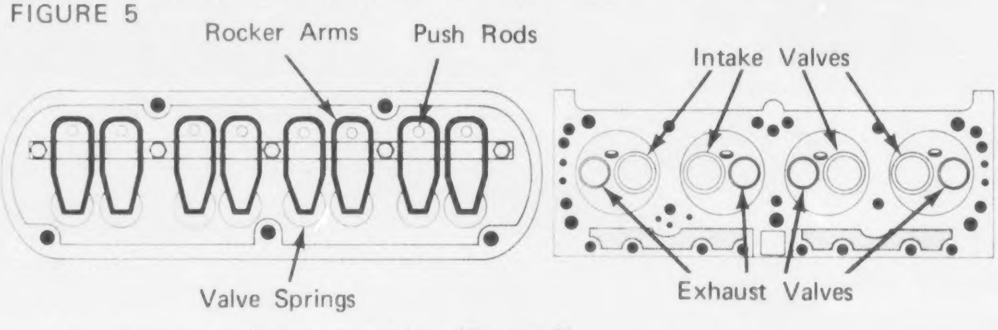
(CAUTION: Use care when breaking the seal between the cylinder head and block to prevent the cylinder head from being damaged or from possibly falling on the floor.)

FIGURE 4


Valve Cover
Rocker Arm Assembly
Valley Chamber Cover
(Only On Some Models)
Push Rod
Cylinder Head Bolt
Cylinder Head

D. Inspect cylinder head for burned valves, broken rocker arms, push rods, head bolts, valve springs, or other visible problems (Figure 5)

FIGURE 5


Rocker Arms
Push Rods
Intake Valves
Valve Springs
Exhaust Valves

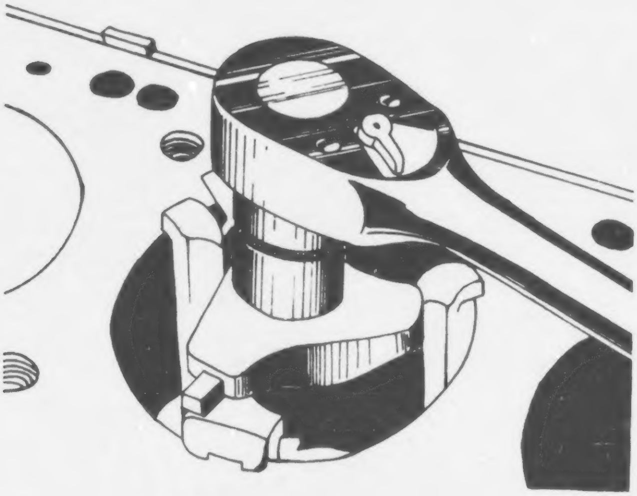
E. Remove cylinder ring ridge (Figure 6)

1. Clean cylinder block gasket surface around cylinders
2. Adjust the cutting tool just smaller than the cylinder diameter
3. Insert cutting tool in the cylinder

JOB SHEET #2

4. Adjust the cutter blade according to tool manufacturer's instructions

FIGURE 6

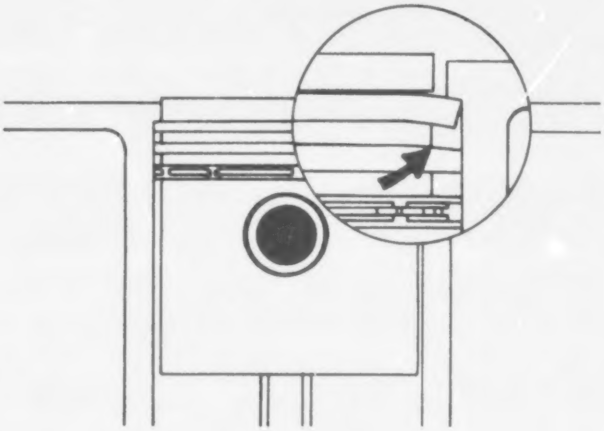


(NOTE: The cutting process should be checked frequently to prevent any damage to cylinder where rings travel.)

5. Cut the ridge out of the top of each cylinder

(CAUTION: Do not attempt to remove pistons from cylinders without cutting the ring ridge because the piston ring lands will be damaged. See Figure 7.)

FIGURE 7



JOB SHEET #2

6. Clean cuttings out of cylinders

F. Remove valve lifters

(NOTE: Store lifters in the order in which they were removed so that they can be reinstalled in their original position.)

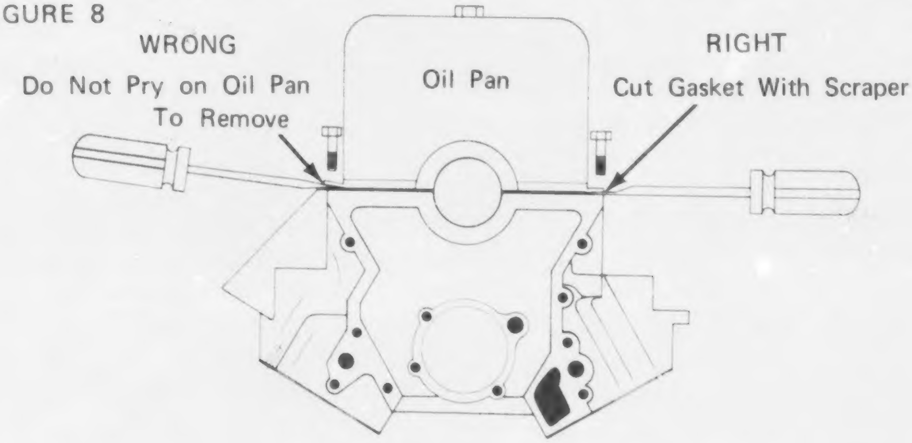
G. Rotate engine on stand so that the oil pan is up

H. Remove oil pan attaching screws

I. Remove oil pan (Figure 8)

(NOTE: Use care not to warp gasket surface of the oil pan as it is unseated.)

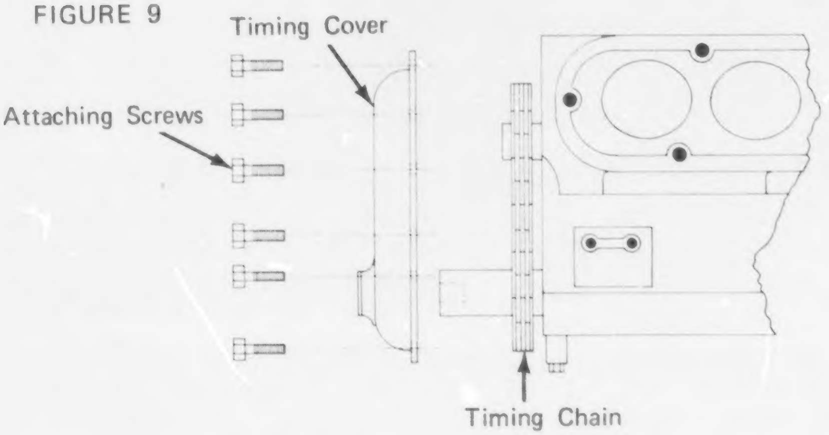
FIGURE 8


WRONG
Do Not Pry on Oil Pan To Remove
Oil Pan
RIGHT
Cut Gasket With Scraper

J. Remove timing cover attaching screws (Figure 9)

K. Remove timing cover (Figure 9)

FIGURE 9


Timing Cover
Attaching Screws
Timing Chain

JOB SHEET #2

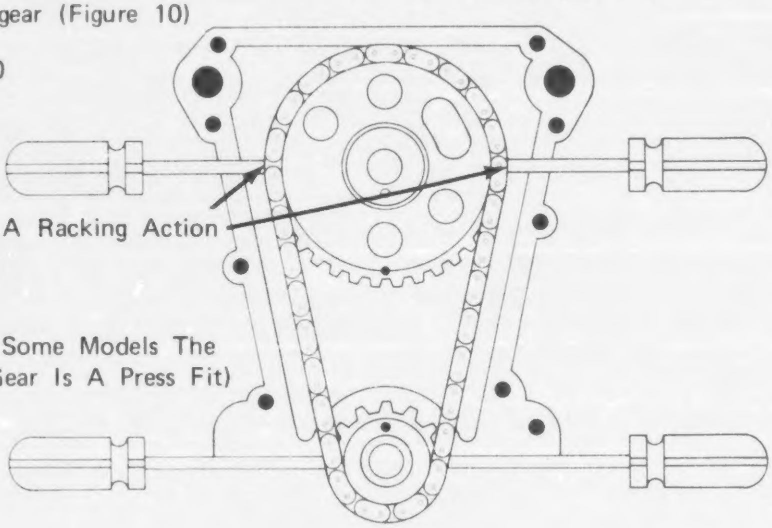
L. Remove fuel pump push rod on models so equipped

M. Remove timing gear retaining bolts or nuts

(NOTE: Some models will have press-on gears and will not have retaining bolts or nuts.)

N. Remove cam gear and chain from camshaft by gently prying out on cam gear (Figure 10)

FIGURE 10

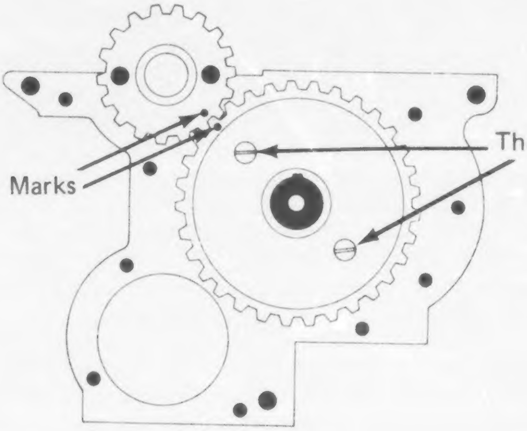


Pry Here With A Racking Action On The Gear

(NOTE: On Some Models The Crankshaft Gear Is A Press Fit)

(NOTE: On models with press-on gears, remove gear and camshaft after removing thrust plate retaining bolts. See Figure 11.)

FIGURE 11



Timing Marks

Thrust Plate Screws

JOB SHEET #2

O. Remove camshaft thrust plate

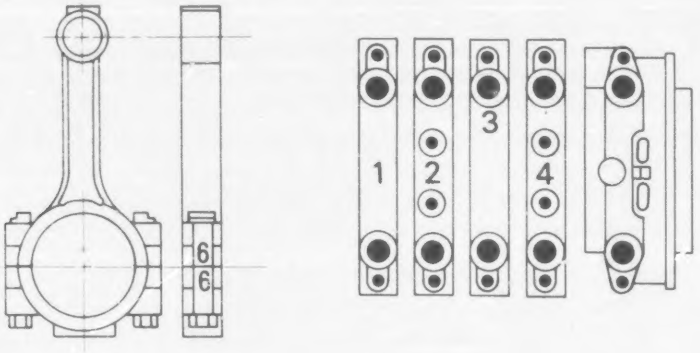
P. Remove oil pump and pickup screen assembly

Q. Remove any oil baffels

R. Remove rear main bearing seal cap if separate from the rear main bearing

S. Check the connecting rods and main caps for identification numbers; number if necessary (Figure 12)

FIGURE 12

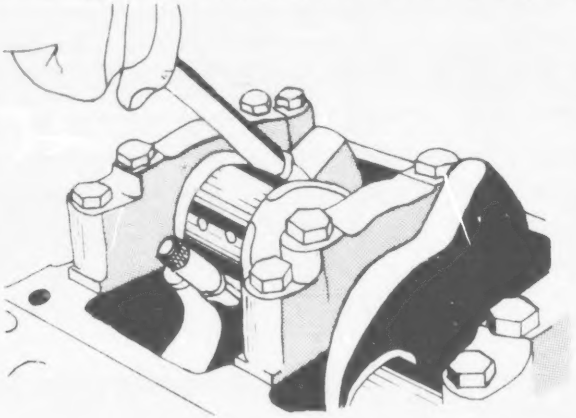


T. Rotate crankshaft until one crankpin is at its highest travel out of the cylinder block

U. Remove the rod cap from one of the connecting rods

V. Attach some type of protection device to both connecting rod bolts (Figure 13)

FIGURE 13



JOB SHEET #2

(NOTE: The crankshaft must be protected from the slightest contact with the rod bolts or other items that might mar the polished bearing surface. Short pieces of vacuum hose make good protection devices, also.)

W. Push the piston and connecting rod assembly out of the cylinder with a wooden hammer handle

(CAUTION: Never use metal objects to remove the piston and connecting rod assembly.)

X. Remove the remaining piston assemblies in the same manner

Y. Replace the rod caps on the correct rod immediately after removal from the engine

Z. Remove all main bearing caps

(NOTE: Be sure the caps are numbered and marked to indicate direction that it is installed in the engine.)

AA. Lift the crankshaft out of the cylinder block with the aid of an assistant

(NOTE: Be sure to keep each main bearing cap bolts with its respective cap.)

BB. Inspect all components visually that have been removed for wear, damage, or any other problem that may require additional parts to be purchased

(NOTE: This inspection should be thorough in order to help evaluate the engine for repair or replacement.)

ENGINE DISASSEMBLY
UNIT III

TEST

NAME ________________________________ SCORE ______________

1. Match the terms on the right to their correct definitions.

   ______a. Device used to heat water to steam and to mix the steam with a detergent that will clean heavy oil and dirt buildup

   ______b. Strong stand suitable for supporting a complete engine in a variety of positions convenient for engine repair

   ______c. Systematic method of removing parts and subassemblies in a particular sequence while looking for worn or damaged parts

   ______d. Complete components of an engine, such as the cylinder head, intake manifold, or water pump

   1. Engine disassembly and inspection
   2. Steam cleaner
   3. Engine subassemblies
   4. Engine repair stand

2. List four safety precautions to observe during engine disassembly.

   a. ____

   b. ____

   c. ____

   d. ____

3. Select from the following list factors to consider when preparing to disassemble an engine. Place an "X" in the correct blanks.

   ______a. Provide a clean, safe place for storage of parts and subassemblies

   ______b. Keep all special braces, spacers, and special bolts with the subassembly to which they belong

   ______c. Make a sketch of the accessories that may be difficult to reinstall

   ______d. Keep tools stacked on the fender cover for quick use ______e. Provide storage trays for bolts, clips, springs, and other subassemblies

______f. Clean outside of engine as much as possible

4. Select from the list below items to inspect during engine disassembly by placing an "X" in the blanks provided.

______a. Cylinder head for visible cracks

______b. Motor mounts for poor banding

______c. Valve train for broken parts

______d. Cylinder block for visible cracks

______e. Cylinder head gaskets

______f. Exhaust header pipe for rust holes

______g. Cylinder block water jacket for sludge buildup

______h. Crankshaft journals

______i. General condition of all observable parts

______j. Crankshaft bearings

______k. Valve for burned condition

______l. General condition of all bolt hole threads

______m. Cylinder block expansion plugs

______n. Radiator for clogged cores

______o. General condition of camshaft

5. Demonstrate the ability to:

a. Clean outside of engine.

b. Disassemble an engine.

(NOTE: If the above activities have not been accomplished prior to the test, ask the instructor when they should be completed.)

ENGINE DISASSEMBLY
UNIT III

ANSWERS TO TEST

1. a. 2
    b. 4
    c. 1
    d. 3
2. Any four of the following:
    a. Keep floor of work area clean and dry at all times
    b. Secure help when handling heavy engine components
    c. Make sure engine is securely attached to engine repair stand
    d. Center the weight on center of pivot of repair stand
    e. Keep tools and work bench clean and orderly
3. a, b, c, e, f
4. a, c, d, e, g, h, i, j, k, l, m, o
5. Performance skills evaluated to the satisfaction of the instructor

VALVE TRAIN AND CYLINDER HEAD RECONDITIONING
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to state the purpose of the valve train and identify parts and repair tools related to it. The student should be able to list causes for valve train problems and discuss the operation of a hydraulic valve lifter. The student should be able to demonstrate the ability to disassemble, inspect, and repair the components of the cylinder head and valve train. This knowledge will be evidenced through demonstration and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with the valve train and cylinder head to the correct definitions.
2. State the purpose of the valve train.
3. Identify the parts of the valve train.
4. Match the parts of the valve train to their correct functions.
5. Select from a list the correct camshaft locations.
6. List methods of driving the camshaft.
7. Identify the parts of the camshaft.
8. Identify the parts of the cam lobe.
9. List the types of valve lifters.
10. Identify parts of a hydraulic valve lifter.
11. Discuss the operation of a hydraulic valve lifter.
12. Identify the parts of a valve.
13. Identify the parts of a valve assembly.
14. Identify types of valve springs and dampering devices.
15. Identify types of valve stem seals.
16. Identify types of valve spring keepers.

17. State the purpose of a valve spring spacer.
18. Identify types of valve rotators.
19. State the purpose of a valve rotator.
20. List reasons a valve must seat properly.
21. Select from a list the major causes of valve burning.
22. Identify tools for valve reconditioning.
23. Demonstrate the ability to:
    a. Inspect timing gears and measure timing chain for stretch and camshaft end play.
    b. Inspect camshaft.
    c. Clean and inspect hydraulic lifters.
    d. Disassemble, clean, and inspect a cylinder head assembly.
    e. Recondition cylinder head.

VALVE TRAIN AND CYLINDER HEAD RECONDITIONING
UNIT IV

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

- A. Provide student with objective sheet.
- B. Provide student with information and job sheets.
- C. Make transparencies.
- D. Secure materials needed for demonstrations.
- E. Discuss unit and specific objectives.
- F. Discuss information sheet.
- G. Demonstrate and discuss procedures outlined on the job sheets.
- H. Give test.

II. Unit references:

A. Crouse, William H. *Automotive Mechanics.* 7th ed. New York: Webster Div./McGraw-Hill Book Co., 1975.

B. *GMC Truck and Coach Division Bulletin X6827.* Pontiac, Michigan: General Motors Corp., no date.

C. *Chassis Overhaul Manual.* Detroit: Chevrolet Motor Div./General Motors Corp., 1977.

D. *Chrysler, Plymouth, Dodge Chassis Service Manual.* Detroit: Chrysler Corp., 1976.

E. *Ford Car Shop Manual.* Dearborn, Michigan: Ford Motor Co., 1975-76.

F. Ellinger, Herbert E. *Automechanics.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1972.

G. Gibbs, Norman E., and Myer, Leo A. *Introductory Automechanics.* San Francisco: Canfield Press, 1976.

VALVE TRAIN AND CYLINDER HEAD RECONDITIONING
UNIT IV

INFORMATION SHEET

I. Terms and definitions

   A. Camshaft--Shaft in the engine which operates the valves through a series of lobes

      (NOTE: The camshaft is sometimes referred to as the *cam*.)

   B. Cam duration--Number of degrees of crankshaft rotation while the valve is open

   C. Cam lift--Distance the valve moves from closed to full open

   D. Valve train--Valve-operating mechanism of the engine

   E. Overhead camshaft--Camshaft that is located in the cylinder head or heads

   F. Cylinder head--That part of an engine that encloses the cylinder bores and contains the water jacket and sometimes the valves

   G. Valve lifter--Cylindrical part of the engine that rests on a cam of the camshaft so that the valve is opened as the cam rotates

      (NOTE: The valve lifter is also called a *tappet* or *cam follower*.)

   H. I-head engine--Engine with the valves in the cylinder head over the cylinder

      (NOTE: This is the most common valve arrangement.)

   I. Valve lash or clearance adjustment--Looseness designed into the valve train so the valve will seat properly

II. Purpose of the valve train--To operate the intake and exhaust valves with piston movement which will cause the four-stroke cycle to occur

III. Parts of the valve train (Transparency 1)

   (NOTE: These are the parts of a valve train in an I-head system with camshaft in cylinder block.)

   A. Valve

   B. Valve spring

INFORMATION SHEET

   C. Rocker arm

   D. Push rod

   E. Valve lifter or tappet

   F. Camshaft

   G. Cam gear

   H. Crankshaft gear

IV. Functions of valve train parts

   A. Valve--Opens and closes the intake and exhaust ports connected to the cylinder

   B. Valve spring--Forces the valve to close

   C. Rocker arm--Changes the direction of motion in the valve train and pushes the valve off of its seat

   D. Push rod--Transmits motion from the lifter to the rocker arm

   E. Lifter (tappet)--Rides along the cam lobe to change rotating motion to reciprocal motion

   F. Camshaft--Operates the valve lifters by rotating cam lobes against the lifters

   G. Cam gear--Turns the camshaft and is used in timing the camshaft to the crankshaft

   H. Crankshaft gear--Drives the cam gear

   (NOTE: The camshaft rotates at one-half the speed of the crankshaft, resulting in a 2:l ratio in the gears.)

V. Camshaft locations (Transparency 2)

   A. In cylinder block

   B. In cylinder head

VI. Methods of driving the camshaft (Transparency 3)

   A. Gear

   B. Chain

   C. Belt

INFORMATION SHEET

VII. Parts of the camshaft (Transparency 4)

   A. Bearing journal

   B. Accessory drive gear

   C. Cam lobe

   D. Thrust face

   E. Retainer plate

   F. Fuel pump eccentric

VIII. Parts of the cam lobe (Transparency 5)

   A. Heel

   B. Ramp

   C. Nose

   D. Valve lift

   E. Valve duration

IX. Types of valve lifters

   A. Solid

   B. Hydraulic

X. Parts of a hydraulic valve lifter (Transparency 6)

   A. Lock ring

   B. Push rod cup

   C. Metering disc

   D. Plunger

   E. Ball

   F. Ball spring

   G. Ball retainer

   (NOTE: The ball, ball spring, and ball retainer make up the check valve assembly.)

   H. Plunger spring

   I. Body

INFORMATION SHEET

XI. Operation of a hydraulic valve lifter (Transparency 7)

  A. Engine oil is fed into the lifter through holes in the undercut area of the lifter body

  B. Oil under pressure inside the plunger pushes the check valve open and fills the area between the bottom of the plunger and the body, causing them to expand and to keep zero clearance in the valve linkage when the lifter is on the heel portion of the cam lobe

  C. Oil is trapped between the plunger and body to maintain plunger position in the lifter body as the lifter rides up the cam lobe

XII. Parts of the valve (Transparency 8)

  A. Head

  B. Margin

  C. Face

  D. Stem

  E. Lock grooves

  F. Chamfer

  G. Lift area

  H. Seal groove (on some types)

XIII. Parts of a valve assembly (Transparency 9)

  A. Valve

  B. Valve seat

  C. Oil seal

  D. Spring

  (NOTE: Some models may have an additional damper or assist spring inside the spring.)

  E. Spring retainer

  F. Keepers

  (NOTE: Keepers are sometimes called *locks* or *keys*.)

INFORMATION SHEET

G. Valve guide, integral or replaceable

(NOTE: Some cylinder heads contain integral valve guides which are cast as part of the head. Others contain replaceable guides which may be driven out and replaced with aid of a driver.)

H. Rotator

XIV. Types of valve springs and dampering devices (Transparency 10)

A. Standard spring

B. Standard spring with inner assist spring

C. Variable rate spring

D. Friction damper spring

E. Friction damper tube

XV. Types of valve stem seals (Transparency 11)

A. Cup or umbrella

B. O-ring

C. Teflon cup

XVI. Types of valve spring keepers (Transparency 12)

A. Pin type

B. Horseshoe

C. Plain conical

D. Single-groove conical

E. Two-groove conical

(NOTE: The single- and two-groove conical valve keepers are the most common types.)

F. Four-groove conical

XVII. Purpose of valve spring spacer--To maintain correct valve spring installed height

(NOTE: The amount needed is equal to the amount of valve face and seat which was ground off during resurfacing procedures.)

INFORMATION SHEET

XVIII. Types of valve rotators (Transparency 13)

A. Free type

(NOTE: The rocker arm exerts pressure on a valve tip cap which exerts pressure on the spring retainer, leaving the valve free to move on the horseshoe type keeper. The engine vibration causes the valve to rotate slightly while the valve is open.

B. Off-center type

(NOTE: The rocker arm offsets slightly from the centerline of the valve. As the valve is opened, there will be a push on the stem. The off-center push tends to make the valve rotate. This is the most common type of valve rotation.)

C. Positive type

(NOTE: The rocker arm exerts a force against the valve stem. The spring retainer portion of the rotator transfers the force to the spring collar through a group of spring loaded balls that ride on a tapered raceway on the spring retainer. This force causes the spring retainer to rotate as the balls roll up the tapered raceway, thus rotating the valve.)

XIX. Purpose of valve rotator--To rotate the valve a small amount each time the valve opens

(NOTE: This provides a wiping action between the valve face and seat to prevent buildup of carbon on the sealing surface and in the valve guide. Carbon buildup in either of these areas will prevent the valve from seating properly and cause it to overheat and burn.)

XX. Reasons a valve must seat properly

A. To make an airtight seal on the combustion chamber

B. To enable the valve to cool

XXI. Causes of valve burning

A. Valve not seating properly

B. Worn valve guides

C. Exhaust heat riser valve stuck in closed position

D. Clogged water jacket or distribution tube causing localized hot spots

INFORMATION SHEET

E. Warped valve seat from improper torqueing of cylinder head

F. Weak or cocked valve springs

G. Insufficient valve tappet clearance

H. Engine overheating

I. Extremely lean air-fuel mixture

J. Preignition and detonation

K. Carbon deposits in the combustion chamber

(NOTE: These are the major causes of valve burning, but there may be other possible causes.)

XXII. Tools for valve reconditioning (Transparencies 14 and 15)

A. Guide cleaner

B. Guide reamer

C. Cylinder head stand

D. Carbon brush

E. Carbon scraper

F. Spring compressor

G. Valve seat indicator

H. Seat grinding pilot

I. Wheel dressing tool (seat grinding)

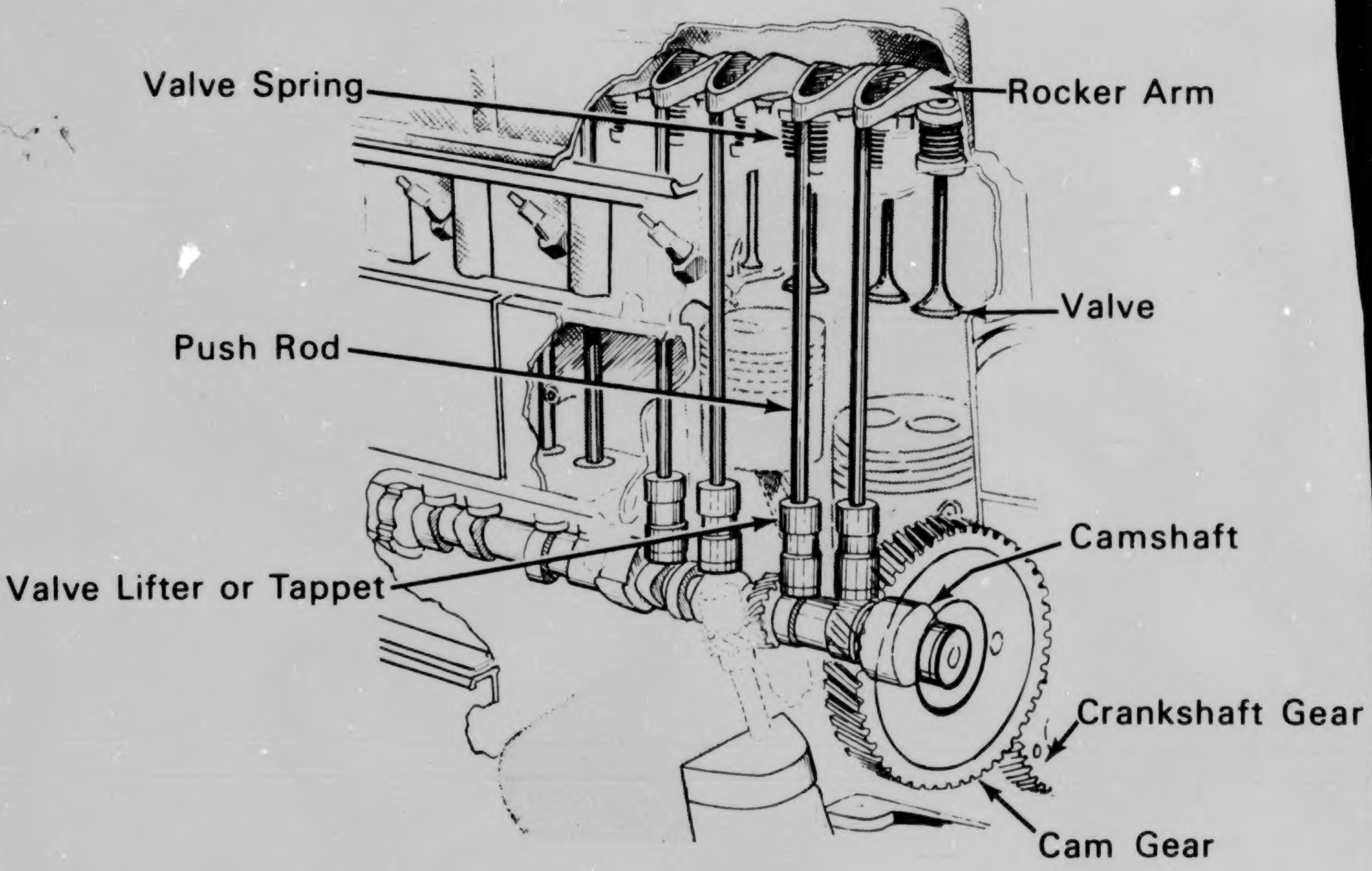
J. Drive motor (seat grinding)

K. Wheel holder (seat grinding)

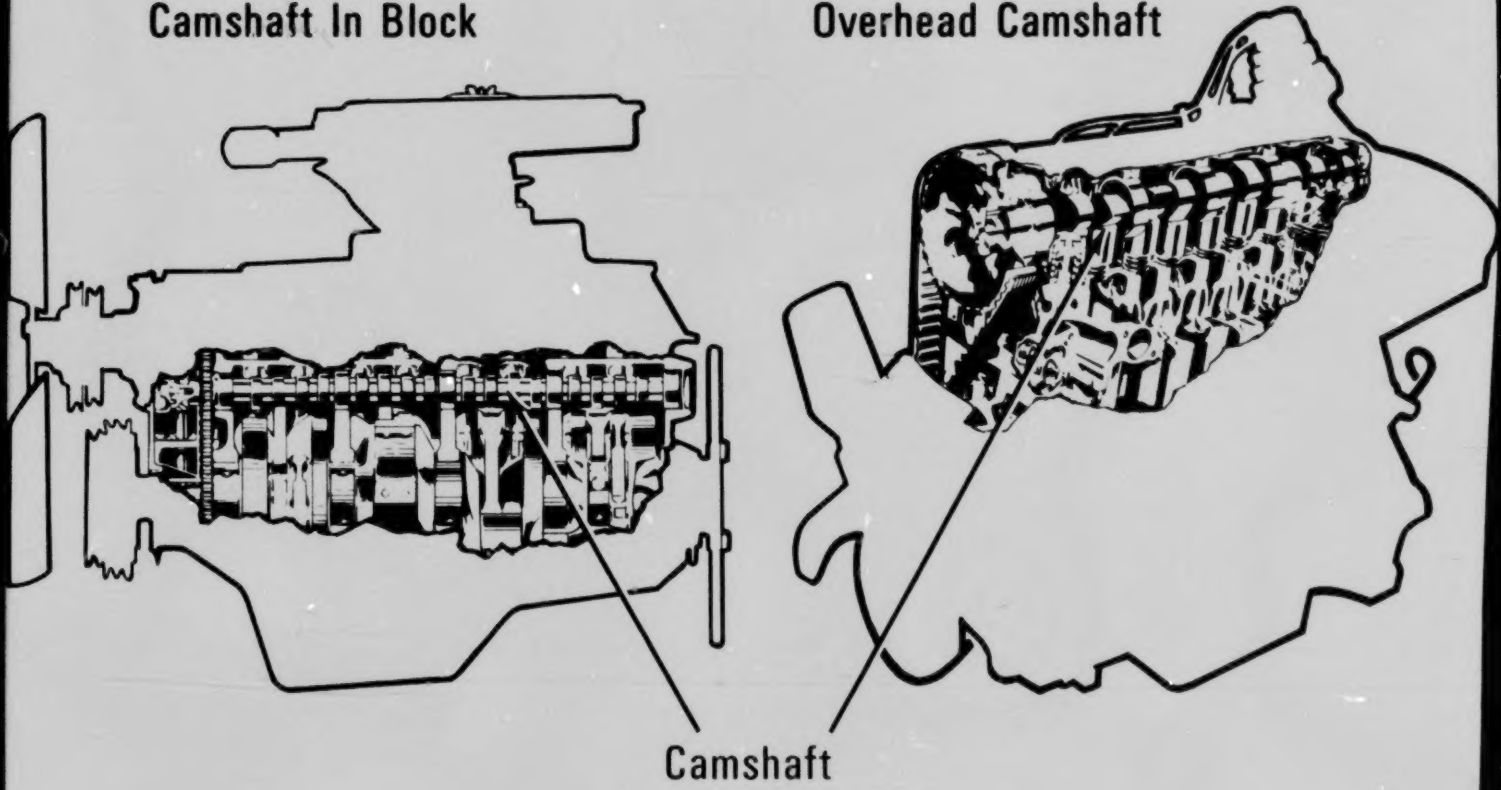
L. Valve grinding machine

M. Valve spring tension gauge

Parts of the Valve Train


Valve Spring
Rocker Arm
Valve
Push Rod
Camshaft
Valve Lifter or Tappet
Crankshaft Gear
Cam Gear

Camshaft Locations

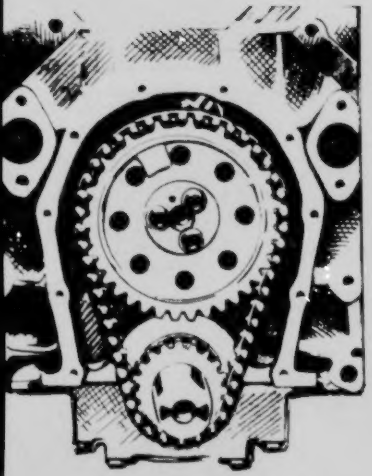


Camshaft In Block

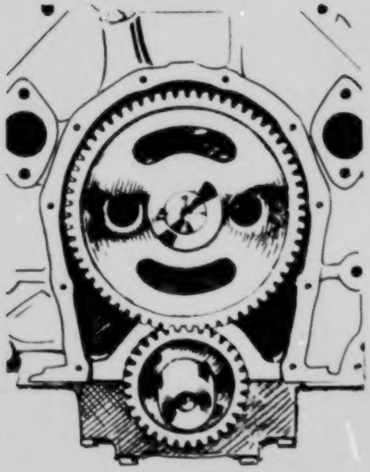
Overhead Camshaft

Methods of Driving the Camshaft

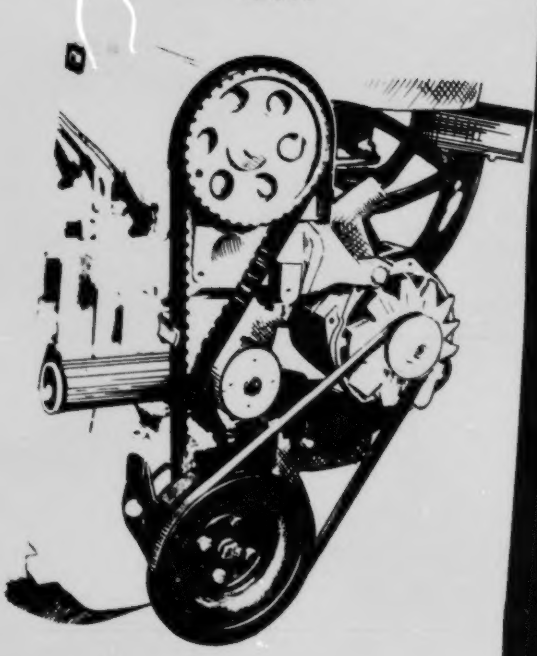
Chain



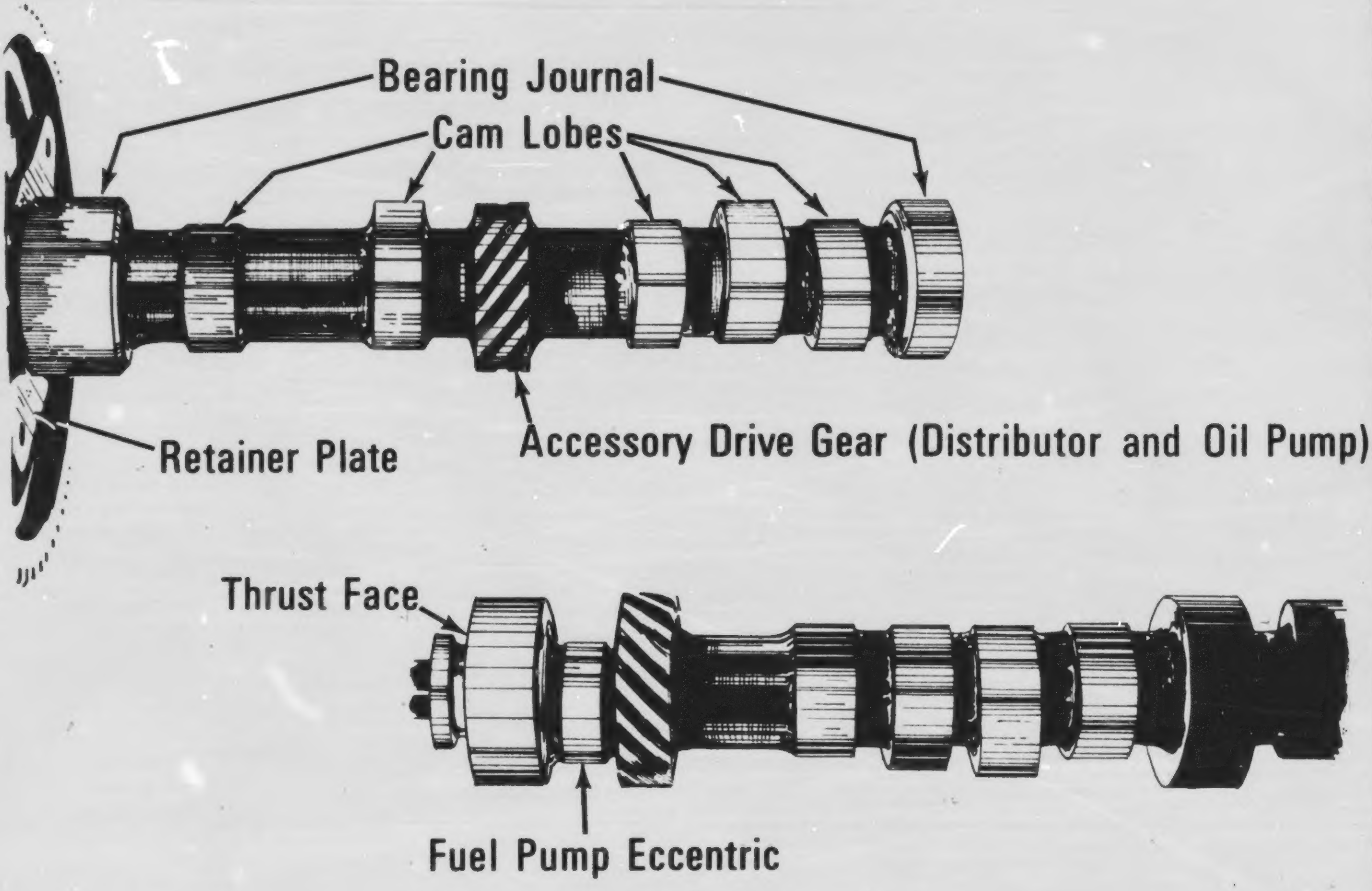
Gear



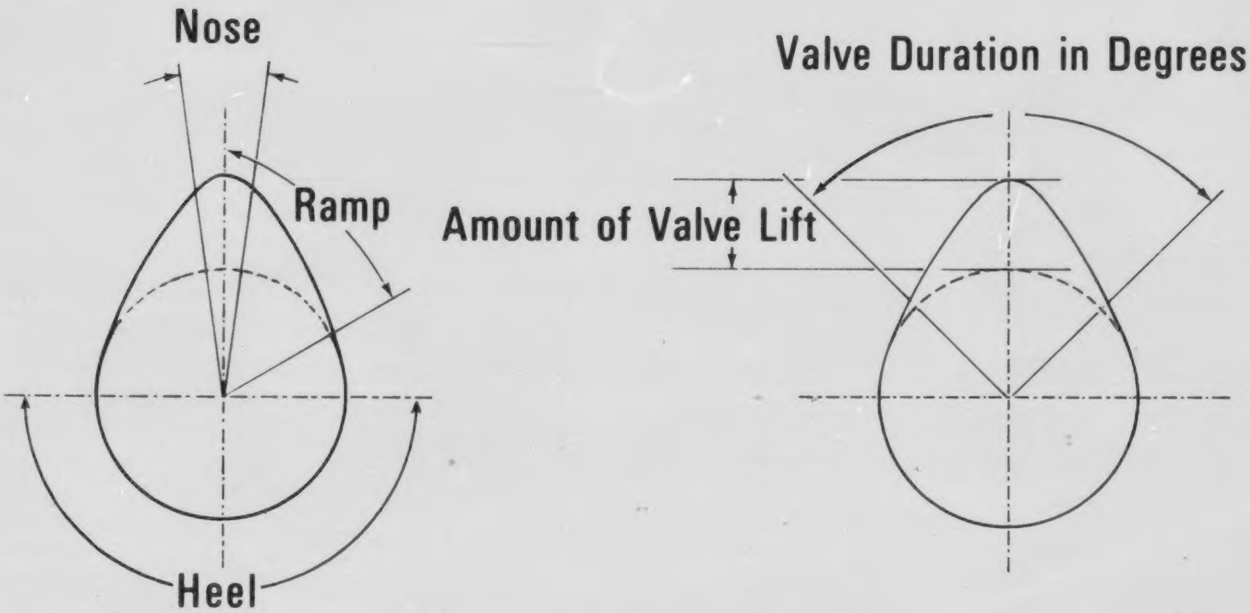
Belt



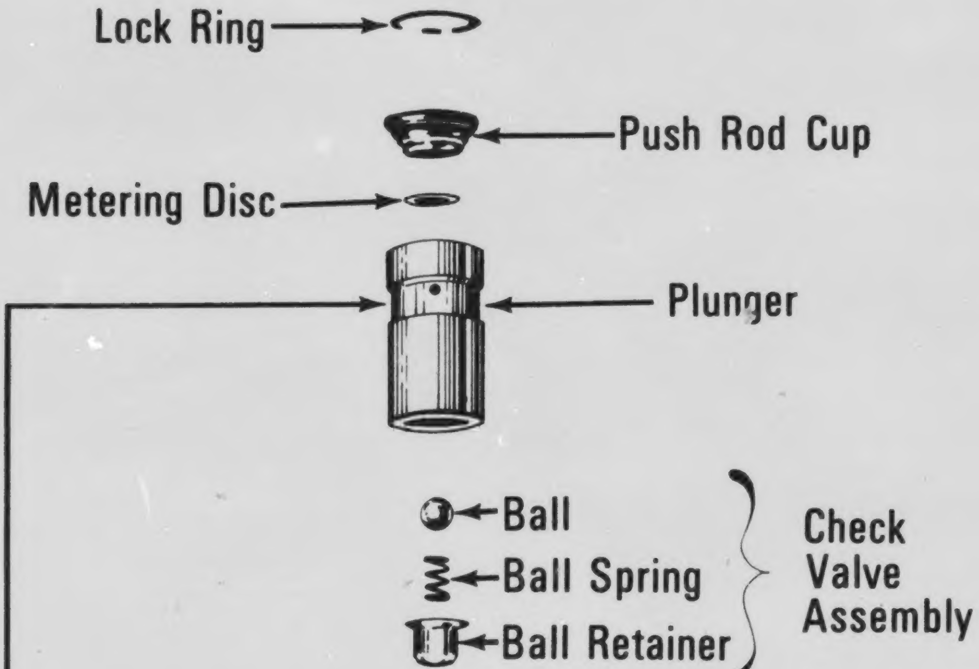
Parts of the Camshaft


Bearing Journal
Cam Lobes
Retainer Plate
Accessory Drive Gear (Distributor and Oil Pump)
Thrust Face
Fuel Pump Eccentric

Parts of the Cam Lobe

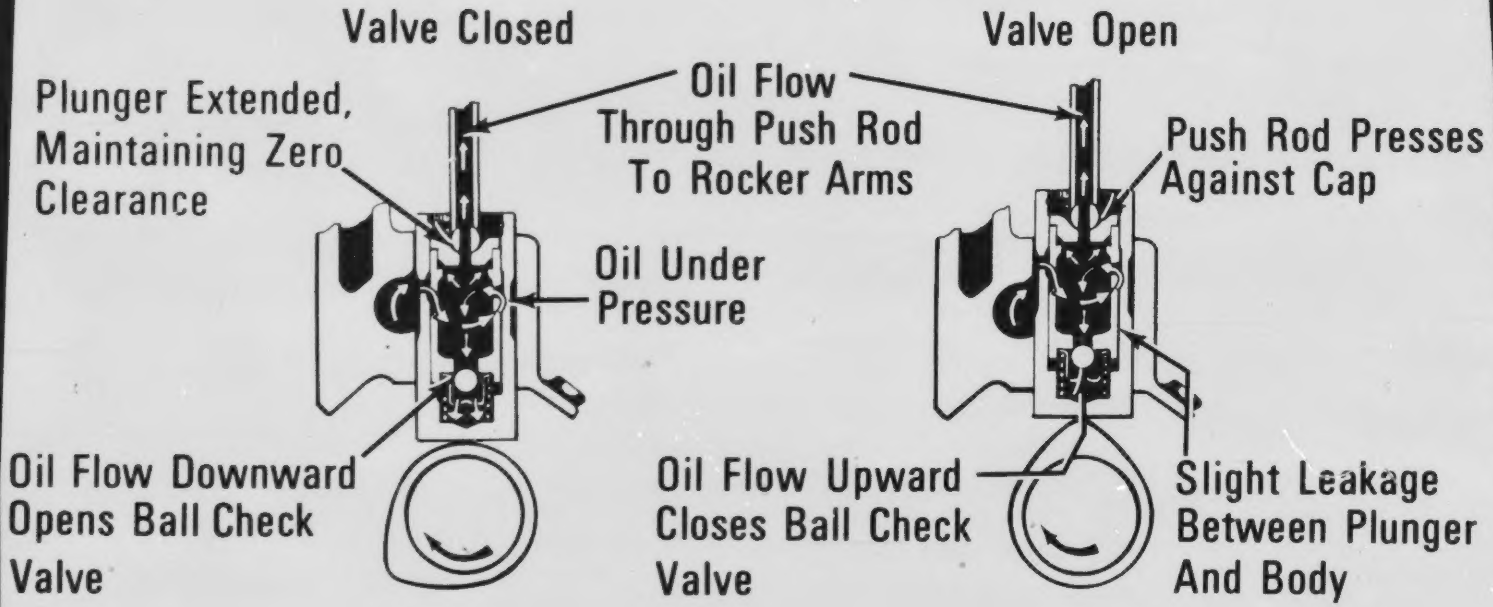

Nose
Ramp
Heel
Amount of Valve Lift
Valve Duration in Degrees

Parts of a Hydraulic Valve Lifter


Lock Ring
Push Rod Cup
Metering Disc
Plunger
Ball
Ball Spring
Ball Retainer
Check Valve Assembly
Plunger Spring
Body

(NOTE: Plunger and body are fitted pairs and must not be mismated.)

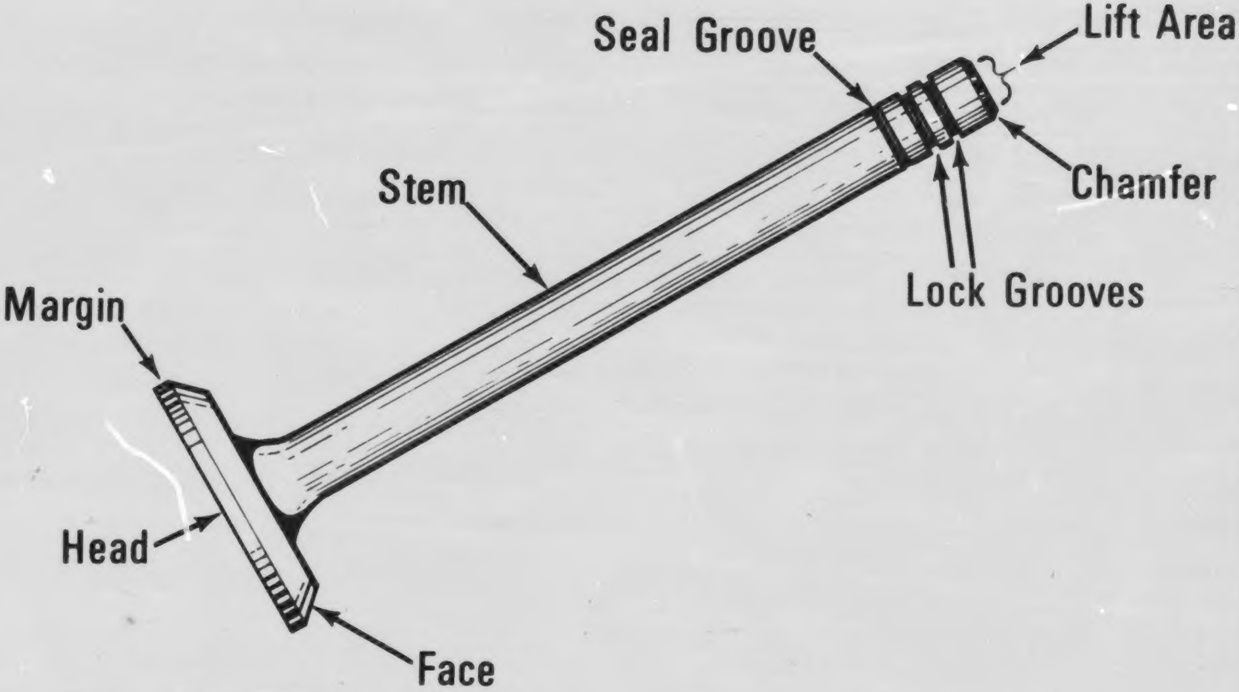
Operation of a Hydraulic Valve Lifter


Valve Closed

Valve Open

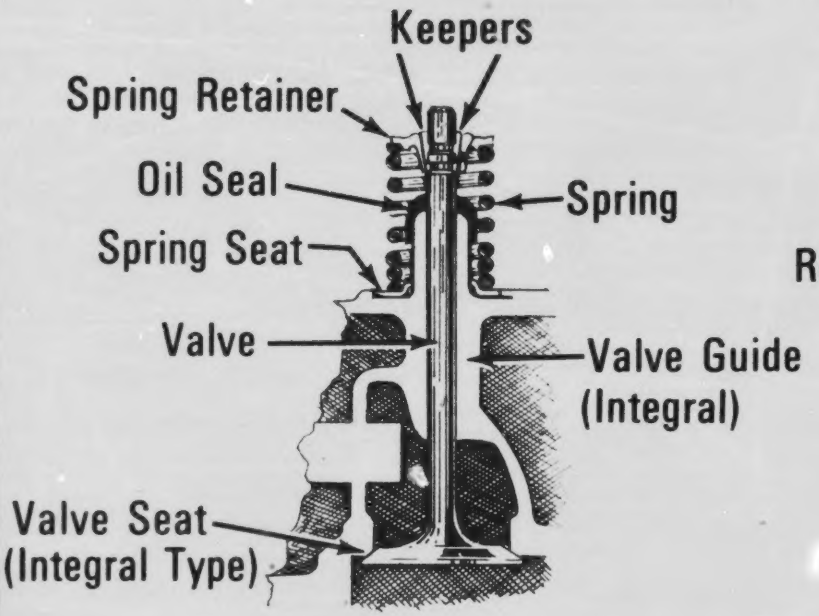
Plunger Extended, Maintaining Zero Clearance
Oil Flow Through Push Rod To Rocker Arms
Push Rod Presses Against Cap
Oil Under Pressure
Oil Flow Downward Opens Ball Check Valve
Oil Flow Upward Closes Ball Check Valve
Slight Leakage Between Plunger And Body

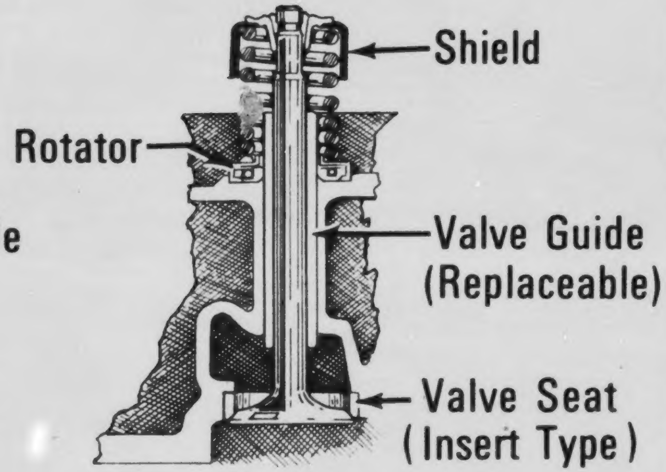
Valve Parts


Seal Groove
Lift Area
Chamfer
Stem
Lock Grooves
Margin
Head
Face

(Note: The lift area on some valves has a hardened surface which should not be machined. Removal of the hard surface would leave soft metal, which could cause the valve stem to wear very fast.)

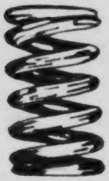
Parts of the Valve Assembly


Keepers
Spring Retainer
Oil Seal
Spring
Spring Seat
Valve
Valve Guide (Integral)
Valve Seat (Integral Type)

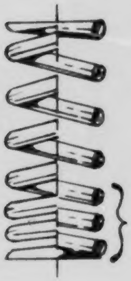

Shield
Rotator
Valve Guide (Replaceable)
Valve Seat (Insert Type)

Types of Valve Springs

Standard Spring

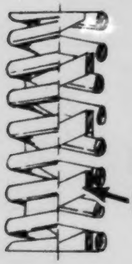


Variable Rate Spring

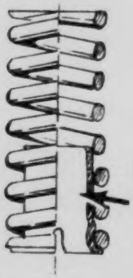


Tighter coils at the bottom are installed next to cylinder head.

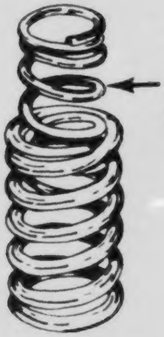
Friction Damper Spring



Friction Damper Tube

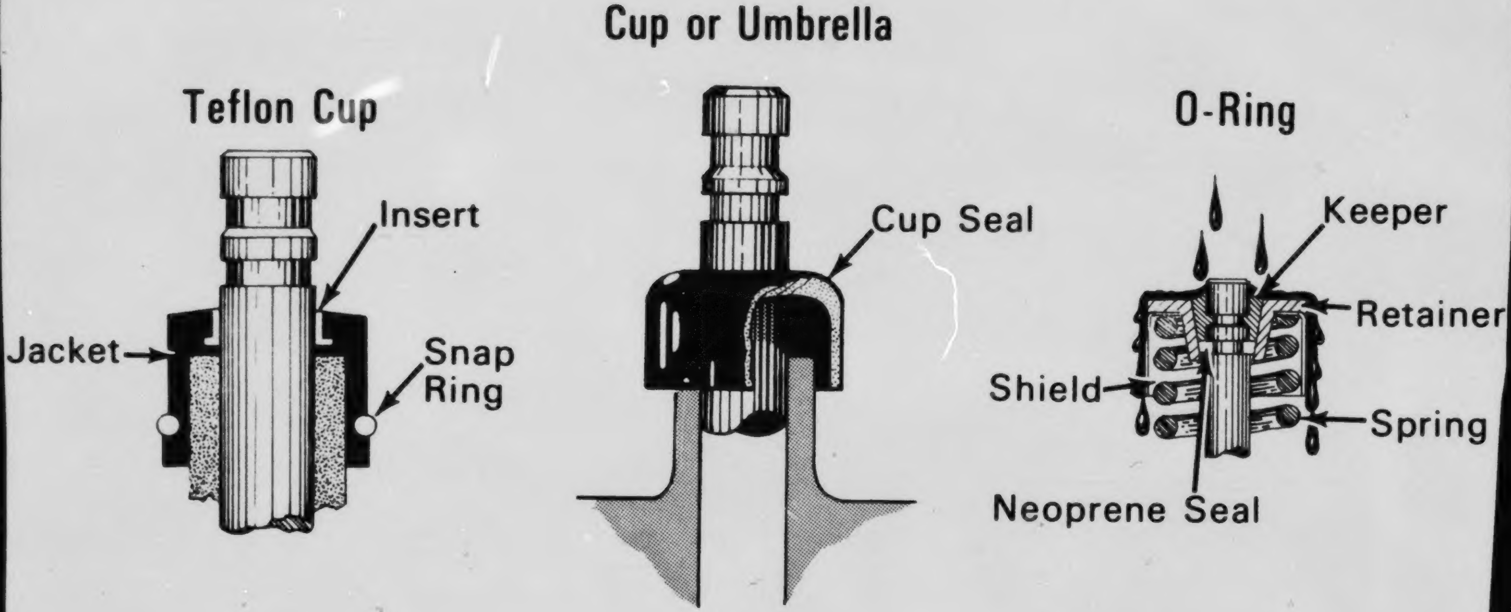


Standard Spring With Inner Assist Spring



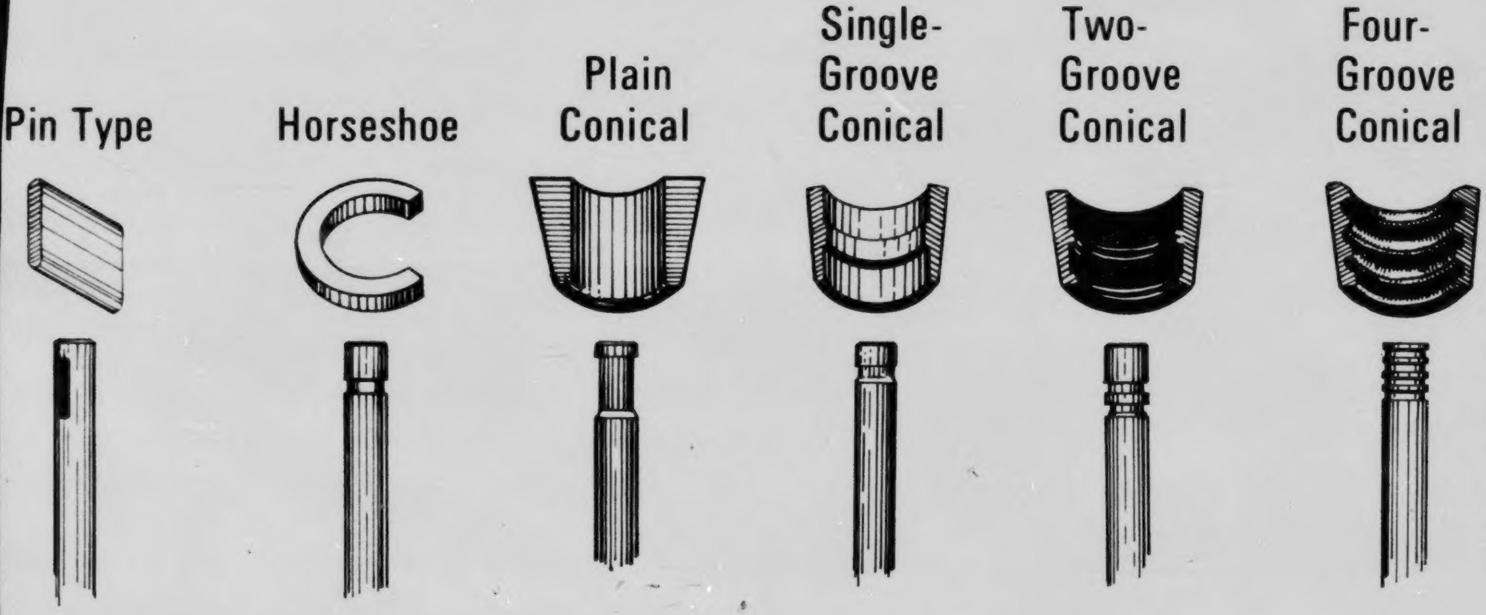
(NOTE: These springs and devices are used to dampen valve spring surge. Spring surge causes the valves to float, causing a knocking noise and usually severe valve train wear or damage.)

Types of Valve Stem Seals

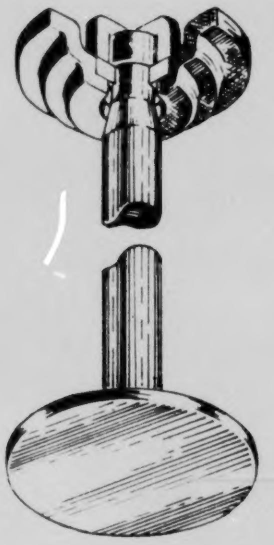

Cup or Umbrella
Teflon Cup
Insert
Jacket
Snap Ring
Cup Seal
O-Ring
Keeper
Retainer
Shield
Spring
Neoprene Seal

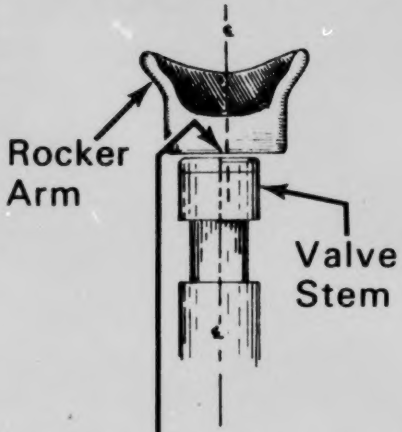
~~[illegible]~~

Types of Valve Spring Keepers


Pin Type
Horseshoe
Plain Conical
Single-Groove Conical
Two-Groove Conical
Four-Groove Conical

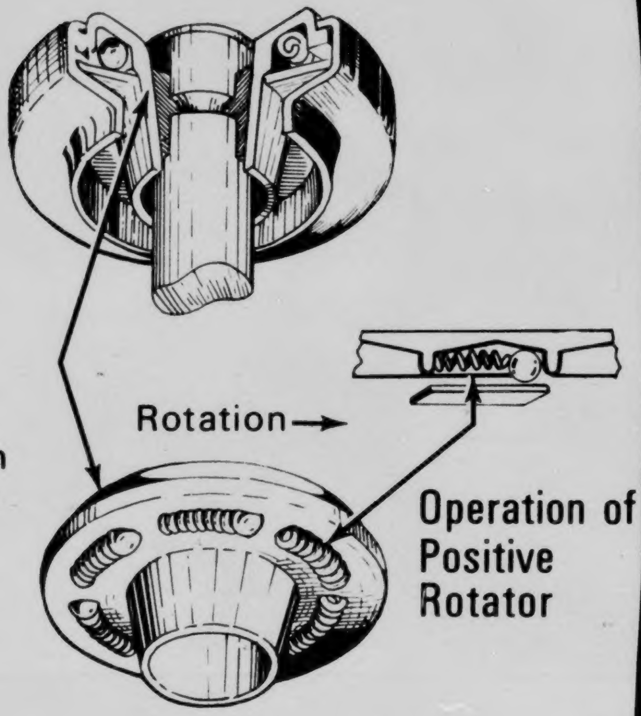
Types of Valve Rotators


Free Type Rotator


Off-Center Type Rotator

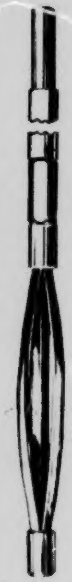
Rocker Arm
Valve Stem

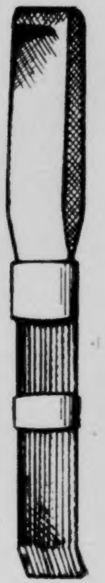
Contact Of Rocker Arm To Valve Is At On Side Of Valve Stem


Positive Type Rotator

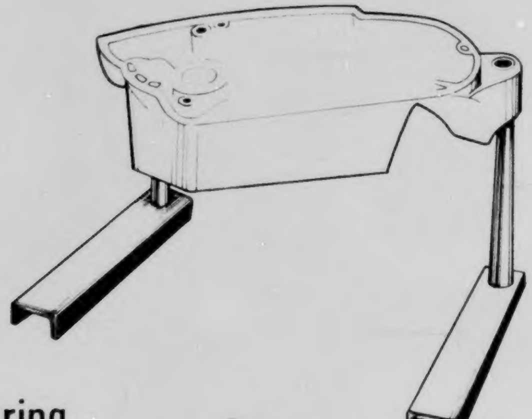
Operation of Positive Rotator

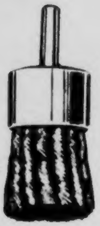
Tools for Valve Reconditioning

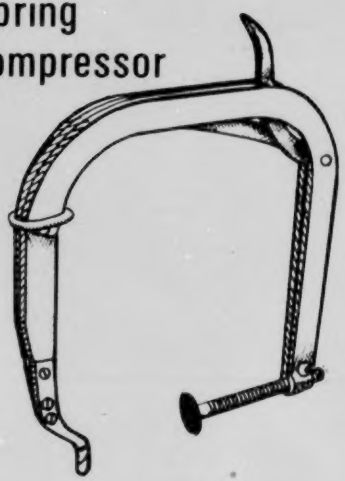

Guide Cleaner

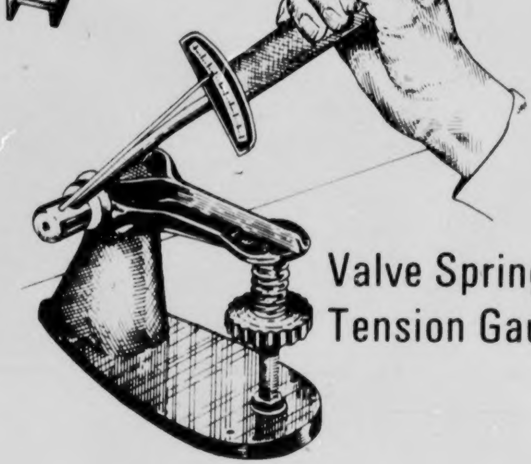

Carbon Scraper

Guide Reamer


Cylinder Head Stand

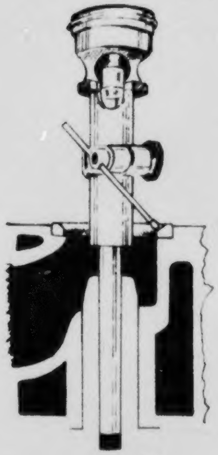

Carbon Brush

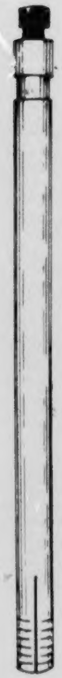

Spring Compressor

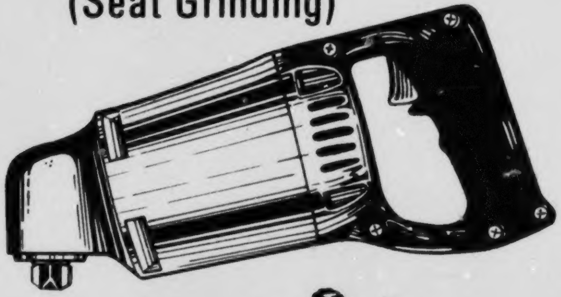

Valve Spring Tension Gauge

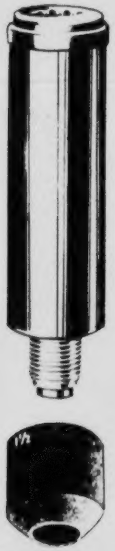
Tools for Valve Reconditioning

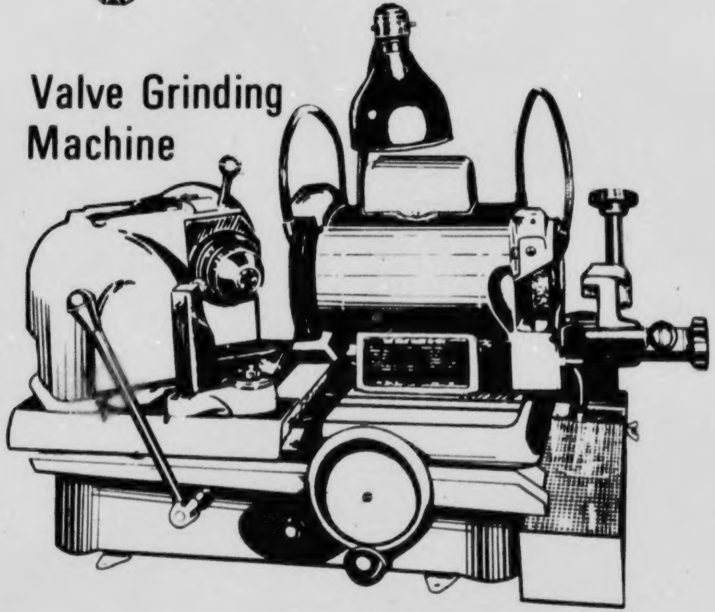
(Continued)

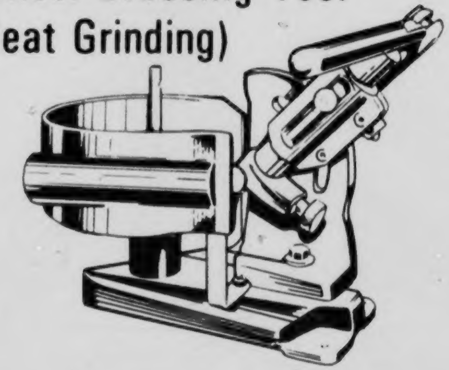

Valve Seat Indicator


Seat Grinding Pilot


Drive Motor (Seat Grinding)


Wheel Holder (Seat Grinding)


Valve Grinding Machine


Wheel Dressing Tool (Seat Grinding)

VALVE TRAIN AND CYLINDER HEAD RECONDITIONING
UNIT IV

JOB SHEET #1--INSPECT TIMING GEARS AND MEASURE TIMING CHAIN FOR STRETCH AND CAMSHAFT END PLAY

I. Tools and equipment

- A. Basic hand tool set
- B. Safety glasses
- C. Torque wrench
- D. Steel rule, 6" (152 mm)

II. Procedure

A. Check timing chain for stretch

1. Place a rule next to the timing chain so that any movement of the chain may be measured (Figure 1)

2. Place a torque wrench and socket over the camshaft bolt and apply torque in the direction of crankshaft rotation to take up slack approximately 20 ft-lbs (27 newton-meters)

   (NOTE: To measure total chain stretch, it may be necessary to block crankshaft from rotating.)

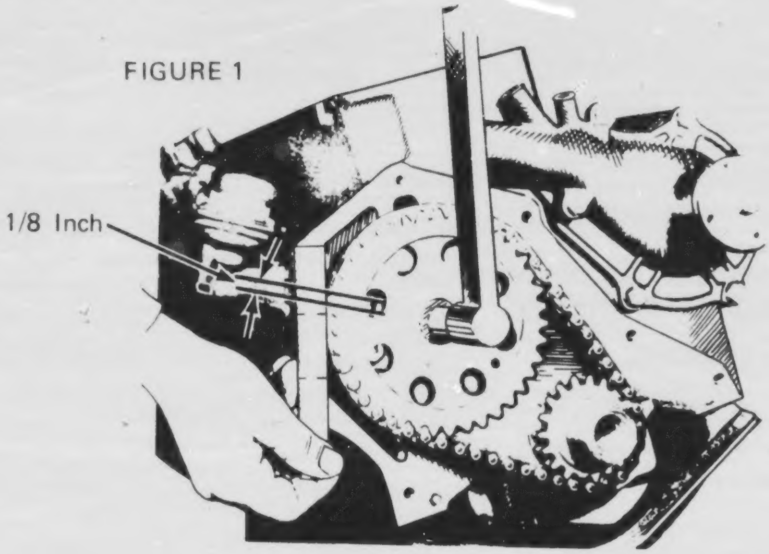
3. Mark a reference position on the timing gear and align the scale with the reference mark

4. Apply torque in the reverse direction approximately 20 ft-lbs (27 newton-meters), enough to take up slack in the chain but not move the crankshaft

JOB SHEET #1

5. Measure chain slack (Figure 1)

FIGURE 1



(NOTE: If movement exceeds one-eighth of an inch [3.17 mm], replace the timing chain.)

B. Inspect timing and crankshaft gears

1. Inspect gear teeth for chipping and grooving

2. Inspect fiber or nylon gears for cracks or flaking

(NOTE: Replace gears if any of the above conditions prevail. Replace the chain and both gears as a set to obtain better performance and longer life.)

(CAUTION: Particles flaking off the nylon timing gear could clog the oil pump pickup screen.)

VALVE TRAIN AND CYLINDER HEAD RECONDITIONING
UNIT IV

JOB SHEET #2--INSPECT CAMSHAFT

I. Tools

  A. V-blocks, 2

  B. Dial indicator

  C. Micrometers, 0 - 3.000" (0 - 76 mm) range

II. Procedure

  A. Inspect camshaft visually

    1. Check journals for grooving or pitting

    2. Check cam lobes for scoring, grooving, or chipping

    3. Check camshaft accessory drive gear for wear or damage

    4. Check fuel pump eccentric for wear or scoring if so equipped

    (NOTE: If any of the above conditions exist, replace the camshaft.)

  B. Measure camshaft end-play

  (NOTE: Camshaft end-play can be measured by dial indicator or feeler gauge. The correct method to use will depend on the type of camshaft thrust plate and cam gear.)

    1. Measure camshaft end-play with a dial indicator

      a. Set up a dial indicator (Figure 1)

      b. Push the camshaft toward the cylinder block until it has bottomed

      c. Adjust the dial indicator contact so that it fits straight against gear edge

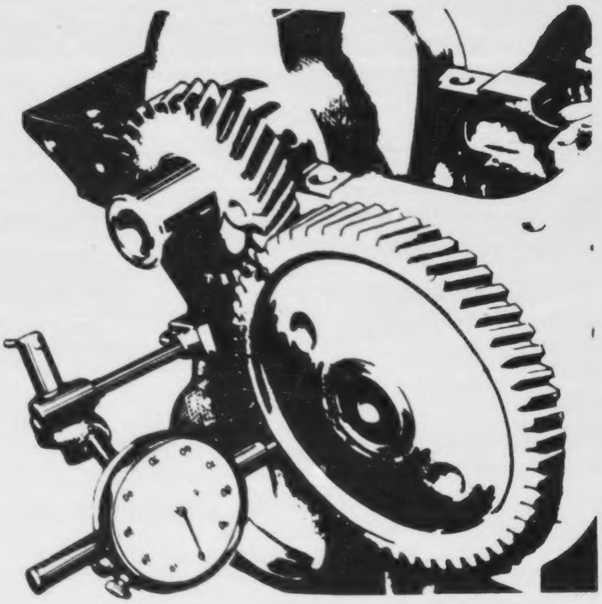
      d. Set dial indicator to 0.000" (0.000 mm)

JOB SHEET #2

e. Pry outward on the camshaft

(CAUTION: Use care to avoid damage while prying on the camshaft.)

FIGURE 1



f. Read dial indicator

g. Compare indicator reading to manufacturer's specifications and repair as necessary

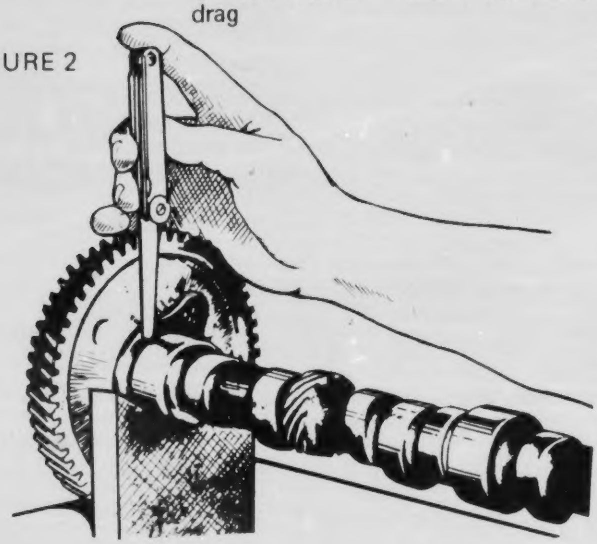
2. Measure camshaft end-play with feeler gauge

   a. Secure cam gear to camshaft (Figure 2)

JOB SHEET #2

b. Select feeler gauge thickness that will slide between the thrust plate and thrust face of the camshaft with a slight drag

FIGURE 2



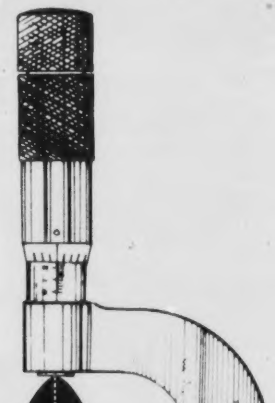
(NOTE: The thickness of the gauge is the end play of the camshaft. Compare this reading with manufacturer's specifications.)

C. Measure camshaft lobe

1. Measure lobe height (Figure 3)

(NOTE: Lobe heights should not vary more than 0.003" [0.0762 mm]. If they do, replace camshaft.)

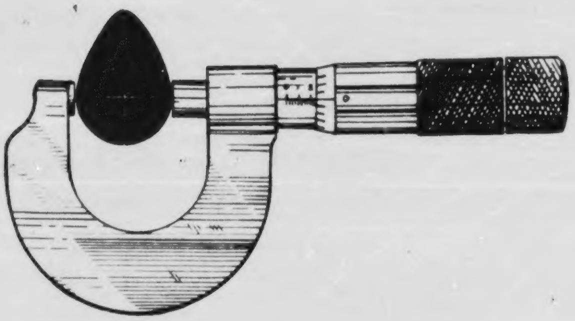
FIGURE 3



2. Measure heel diameter of each lobe and compare to determine wear (Figure 4)

   (NOTE: Lobe heel diameter should not vary more than 0.001" [0.0254 mm].)

FIGURE 4



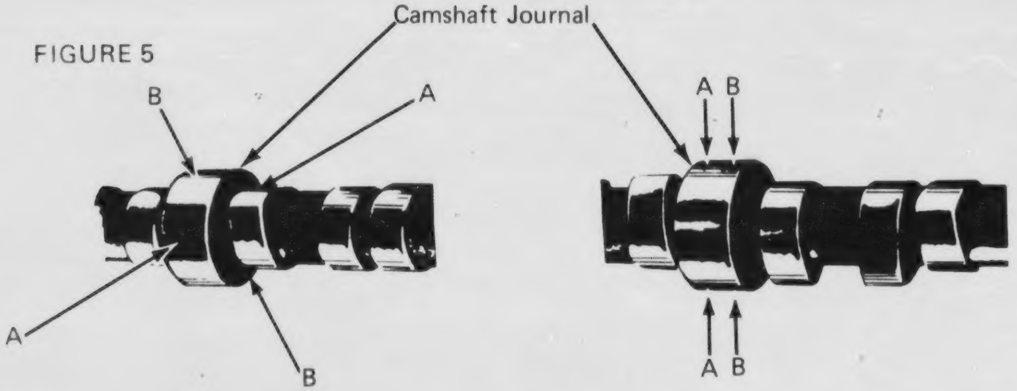
D. Measure camshaft journals (Figure 5)

   1. Check each journal for out-of-round condition

   2. Check each journal for taper

   (NOTE: Journal out-of-round or taper should not exceed 0.001" [0.0254 mm].)

FIGURE 5



Compare measurements A and B for out-of-round condition

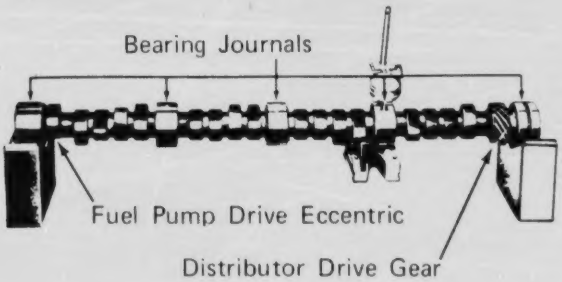
Compare measurements A and B for journal taper condition

JOB SHEET #2

E. Check camshaft runout (Figure 6)

1. Place camshaft on V-block so that the shaft is supported by the end bearing journals
2. Position the dial indicator so it contacts squarely on bearing journal
3. Rotate shaft to locate position of lowest reading
4. Adjust the indicator to zero reading
5. Rotate the camshaft one complete turn slowly while watching for highest meter reading

FIGURE 6


Bearing Journals
Fuel Pump Drive Eccentric
Distributor Drive Gear

(NOTE: Check all inner shaft bearing journals in the same manner. If runout exceeds 0.003" [0.0762 mm] dial indicator reading, replace the camshaft.)

VALVE TRAIN AND CYLINDER HEAD RECONDITIONING
UNIT IV

JOB SHEET #3--CLEAN AND INSPECT HYDRAULIC LIFTERS

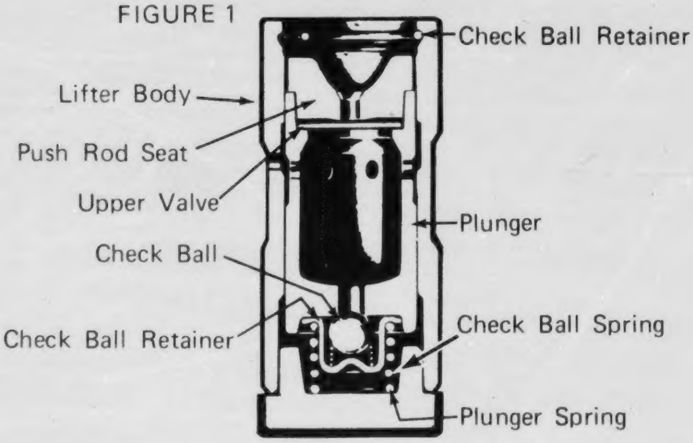
I. Tools and equipment

- A. Basic hand tool set
- B. Safety glasses
- C. Cleaning solvent
- D. Cleaning basket with separate compartments
- E. Motor oil, SAE 10
- F. Drift pin, 1/8" (3.17 mm)
- G. Drift pin, 1/16" (1.58 mm)

II. Procedure

- A. Inspect the lifter visually for wear or damage on the base and for wear on the push rod seat; replace if any damage or wear is evident
- B. Disassemble hydraulic lifter (Figure 1)

FIGURE 1


Check Ball Retainer
Lifter Body
Push Rod Seat
Upper Valve
Plunger
Check Ball
Check Ball Spring
Check Ball Retainer
Plunger Spring

1. Hold the plunger down with a push rod
2. Remove the push rod seat retainer ring
3. Remove push rod slowly

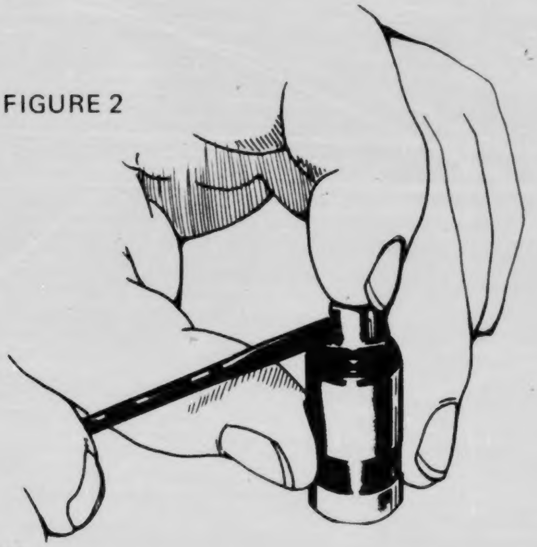
JOB SHEET #3

4. Remove push rod seat and upper valve

5. Remove the plunger, ball check valve, and plunger spring

6. Remove the ball check valve and spring from the plunger by prying the ball retainer with the blade of a small screwdriver (Figure 2)

FIGURE 2



C. Clean and inspect lifter

1. Clean all parts thoroughly in cleaning solvent

   (CAUTION: If more than one lifter is repaired at the same time, use caution not to interchange parts.)

2. Inspect for worn or scuffed parts in the lifter

   (NOTE: If any one part is damaged, the entire lifter assembly should be replaced. If the outside of the lifter body is scuffed or worn, inspect the cylinder block lifter bore. If the bottom of the lifter is scuffed or worn, inspect the camshaft lobe. If the push rod seat is scuffed or worn, inspect the push rod.)

D. Assemble the hydraulic lifter

1. Place the check ball on the small hole on the bottom of the plunger

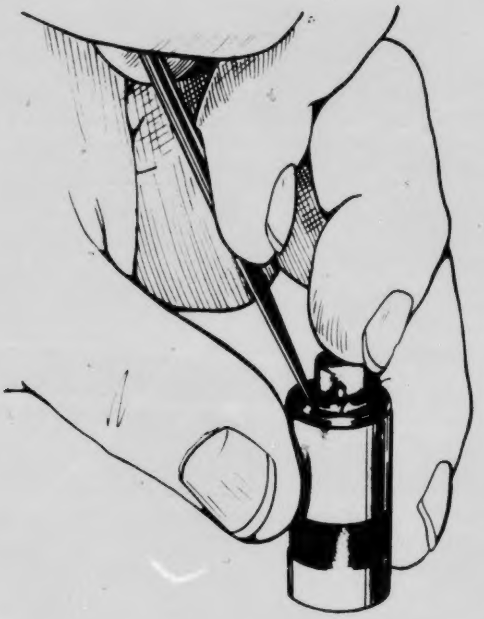
2. Insert check ball spring on seat in ball retainer

3. Place retainer over ball so spring rests on the ball

JOB SHEET #3

4. Press the retainer into position in the plunger carefully with the blade of a small screwdriver (Figure 3)

FIGURE 3



5. Place the plunger spring over the ball retainer

6. Slide the lifter body over the spring and plunger, being careful to line up the oil feed holes in the lifter body and plunger

7. Fill the assembly with SAE 10 oil

8. Insert the end of a 1/8" (3.17 mm) drift pin into the plunger and press down solid

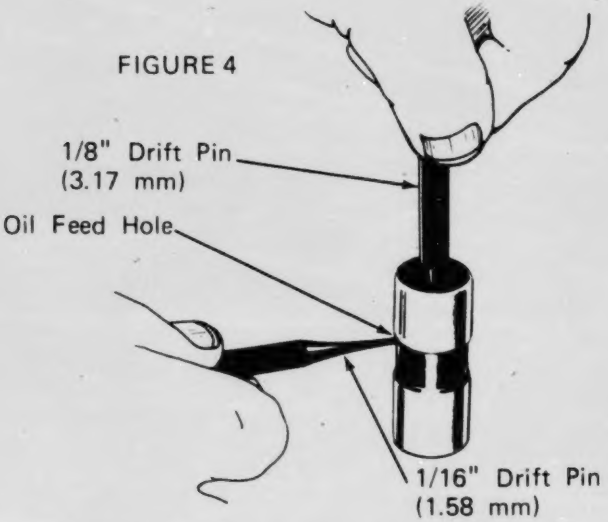
   (NOTE: At this point the holes in the lifter body and plunger assembly will be aligned.)

   (CAUTION: Do not attempt to force or pump the plunger or severe damage could result to the lifter.)

JOB SHEET #3

9. Insert a 1/16" (1.58 mm) drift pin through both oil holes to hold the plunger against the spring tension (Figure 4)

FIGURE 4



(CAUTION: Use care not to damage internal parts of the lifter with either drift pin.)

10. Remove the 1/8" (3.17 mm) drift pin
11. Refill assembly with SAE 10 oil
12. Insert the upper valve and push rod seat
13. Install the push rod seat retainer
14. Push down on the push rod seat and remove the 1/16" (1.58 mm) drift pin from the oil holes

(NOTE: The lifter is now completely assembled, filled with oil, and ready for installation. Before installing any lifter, coat the bottom of the lifter with a good high pressure lubricant such as Malykote or its equivalent.)

VALVE TRAIN AND CYLINDER HEAD RECONDITIONING
UNIT IV

JOB SHEET #4--DISASSEMBLE, CLEAN, AND INSPECT A CYLINDER HEAD ASSEMBLY

I. Tools and equipment

   A. Valve spring compressor

   B. Drill motor

   C. Valve guide cleaner

   D. Carbon brush

   E. Dial indicator and adapter set

   F. Torque wrench

   G. Valve spring tension gauge

   H. Gasket scraper

   I. Carbon scraper

   J. Straightedge

   K. Feeler gauge assortment

   L. Cleaning solvent

   M. Bench-mounted buffing wheel

   N. Vat type cleaner (optional)

   O. Valve board

   P. Basic hand tool set

   Q. Safety glasses

II. Procedure

   A. Disassemble cylinder head

      1. Remove rocker arms, if not previously done

      2. Loosen valve keepers by striking a downward blow on the spring retainer

JOB SHEET #4

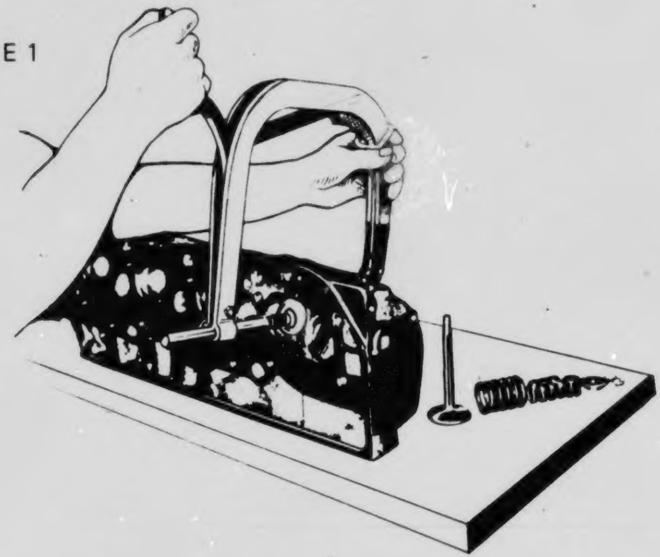
3. Compress valve springs and remove valve keys (Figure 1)

   (CAUTION: Point the valve spring so that it will hit the bench or wall if the compressor should slip off.)

4. Release compressor slowly and remove spring assembly (Figure 1)

5. Remove valve stem seal (Figure 1)

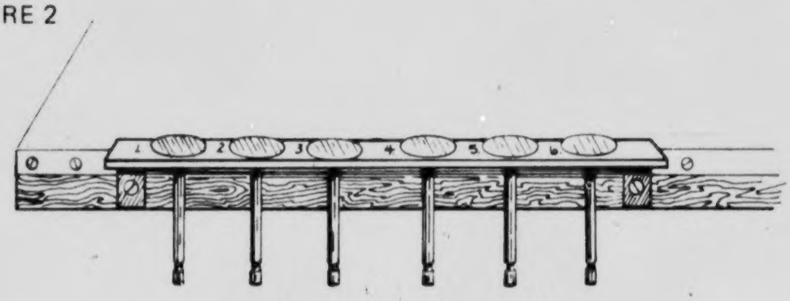
FIGURE 1



6. Remove any burrs or mushroomed conditions from valve stem before attempting to remove the valve from the head

7. Remove valves from cylinder head and place on a rack in their proper sequence so they can be reassembled in their original positions (Figure 2)

FIGURE 2

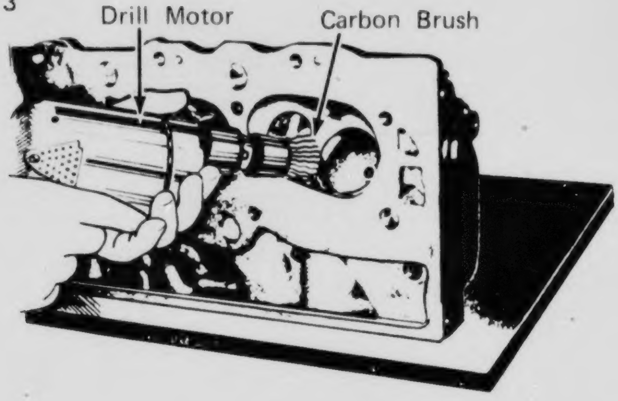


JOB SHEET #4

B. Clean cylinder head and valve parts

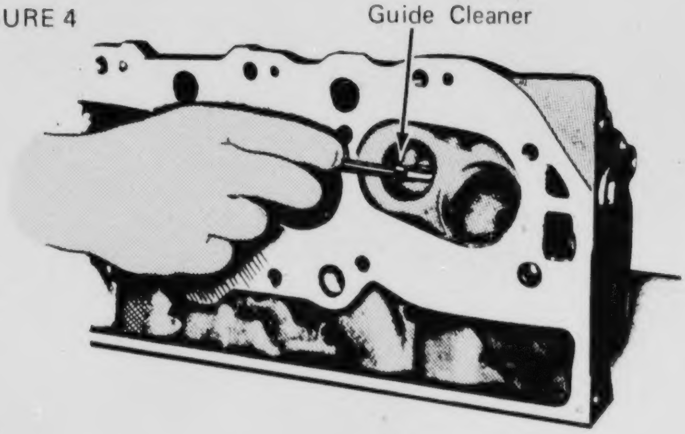
1. Clean all carbon from combustion chambers and head surfaces (Figure 3)

FIGURE 3


Drill Motor
Carbon Brush

2. Clean valve guides using guide cleaner (Figure 4)

FIGURE 4


Guide Cleaner

a. Adjust the blades of cleaner to fit the guide snugly

b. Install cleaner in drill motor

JOB SHEET #4

   c. Dip cleaners in solvent and insert in guide

   d. Spin cleaner in guide while moving cleaner up and down the guide

3. Clean all carbon and sludge from push rods, rocker arms, and push rod guides

4. Clean valve stems and heads on a buffing wheel

5. Clean carbon and gasket material from cylinder head gasket mating surfaces

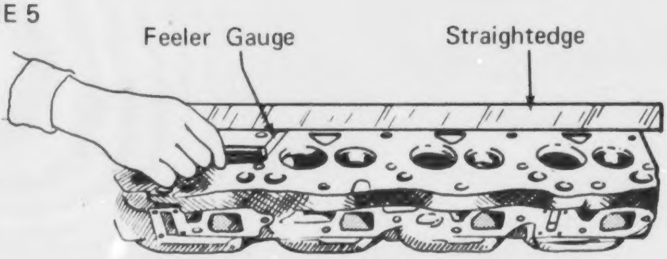
G. Inspect cylinder head and valve assemblies

1. Inspect the cylinder head for cracks in the exhaust ports, combustion chambers, or cracks in the water chamber

   (NOTE: Suspected cracks may be tested with Magniflux or other suitable crack-detecting equipment.)

2. Check cylinder head gasket mating surface for warpage (Figure 5)

FIGURE 5



   (NOTE: If an 0.004" [0.1016 mm] feeler gauge will go between the head surface and straightedge at any position, the cylinder head will require resurfacing.)

3. Check all bolt hole threads

4. Inspect the valves for burned heads, cracked faces, or damaged stems

5. Measure valve stem clearance (Figure 6)

   a. Clamp a dial indicator on the side of the cylinder head

JOB SHEET #4

b. Locate the indicator so that movement of the valve stem from side to side will cause a direct movement of the indicator stem

(NOTE: The indicator stem must contact the valve stem just above the valve guide.)

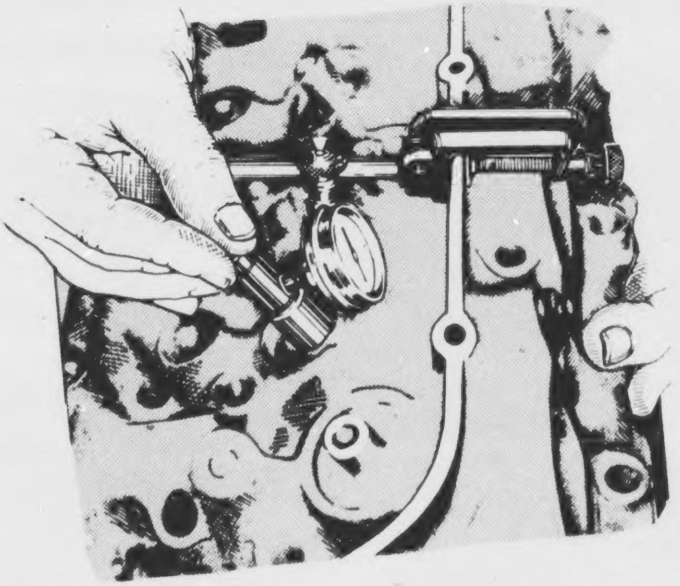
c. Lower the valve head about 1/16" (1.58 mm) off the valve seat

(NOTE: A new valve should be used to accurately determine valve guide wear.)

d. Move the stem of the valve from side to side, using light pressure, to obtain a clearance reading

(NOTE: Refer to specifications to determine the proper clearance and the repairs that may be necessary.)

FIGURE 6



6. Check valve spring tension

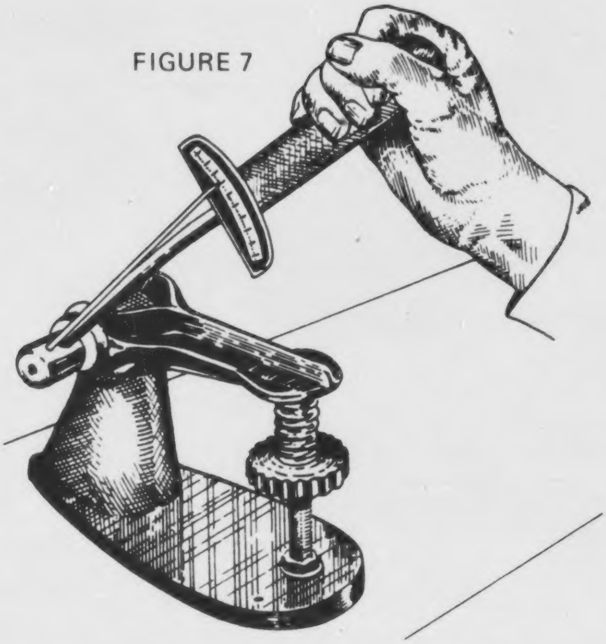
a. Compare valve spring free-standing height

(NOTE: Springs should be within 1/8" (3.17 mm) of each other without leaning or other distortions.)

JOB SHEET #4

b. Check valve spring with spring tester (Figure 7)

FIGURE 7



(NOTE: Spring should be compressed to the specified height and checked against the specification chart for torque. Springs should be replaced if not within 10 ft-lbs [13.55 newton-meters] of the specified load.)

7. Inspect push rod condition

   a. Inspect push rods for straightness

      (NOTE: This can be accomplished by rolling the push rod on a flat surface and watching for a wobbling condition.)

   b. Inspect push rod ends for wear, chipping, or other damage

8. Inspect rocker arms

   a. Inspect rocker arms for wear at push rod seat, valve stem reaction area, and shaft or pivot area

   b. Inspect rocker arm shaft, if so equipped, for wear, scoring, or cracks

JOB SHEET #4

c. Inspect rocker arm studs, if so equipped, for wear, looseness in cylinder head, or damaged threads

d. Inspect rocker arm stands, studs, and pivot balls for wear or damage

VALVE TRAIN AND CYLINDER HEAD RECONDITIONING
UNIT IV

JOB SHEET #5--RECONDITION CYLINDER HEAD

I. Tools and equipment

- A. Basic hand tool set
- B. Torque wrench
- C. Rocker arm stud puller
- D. Rocker arm stud driver
- E. Valve seat grinding equipment
- F. Valve grinding equipment
- G. Valve spring compressor
- H. Steel scale, 6" in 1/32" increments (152 mm in 1-mm increments)
- I. Lead pencil
- J. Assortment of guide reamers
- K. Valve seat indicator

II. Procedure

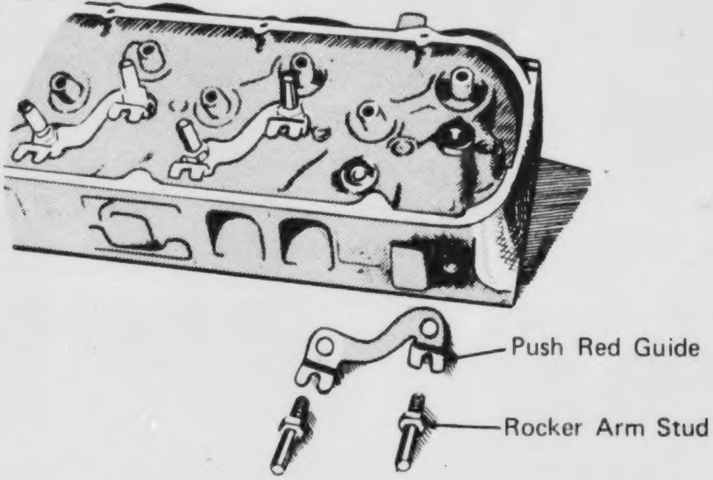
- A. Replace rocker arm studs
  - 1. Replace threaded type stud
    - a. Unscrew old rocker arm stud

      (NOTE: Some rocker studs retain the push rod guides which must be replaced in the same position.)
    - b. Coat threads of the stud on the cylinder head end with sealer

JOB SHEET #5

c. Install stud and torque to specifications (Figure 1)

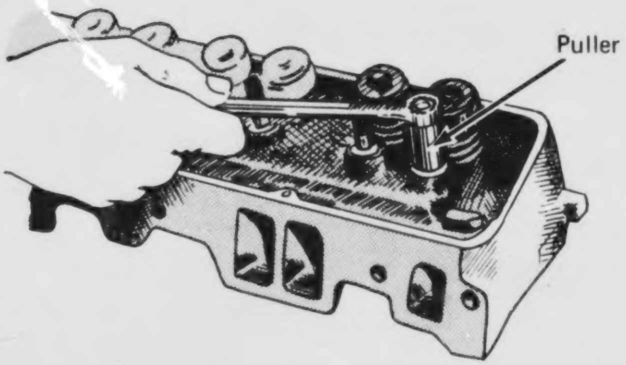
FIGURE 1


Push Red Guide
Rocker Arm Stud

2. Replace press-in type stud

   a. Remove old stud with stud puller (Figure 2)

FIGURE 2



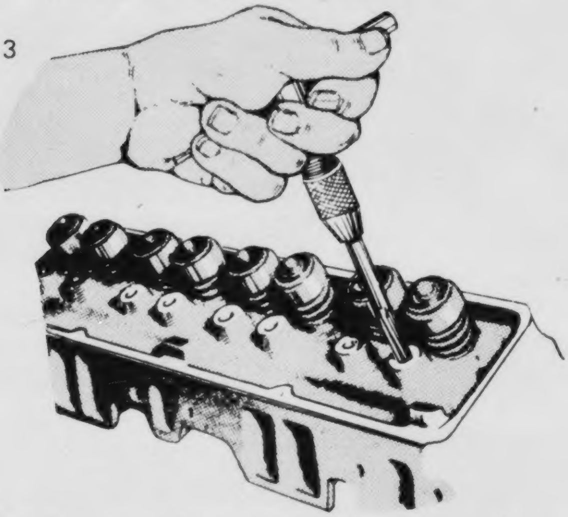
(NOTE. Lubricate threads and puller surface to aid in pulling the stud. The puller could be a short piece of pipe or a stack of washers.)

JOB SHEET #5

b. Ream stud hole to fit the oversize stud (Figure 3)

(CAUTION: Do not attempt to install an oversize stud without reaming stud hole.)

FIGURE 3

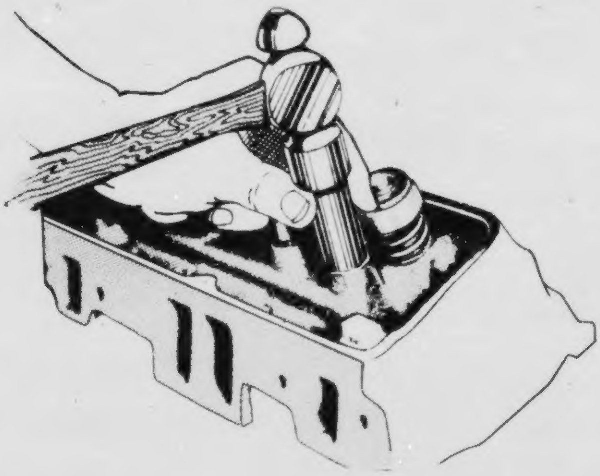


c. Coat press-fit area of stud with hypoid axle lubricant

(CAUTION: Avoid trapping any lubricant in the stud hole because this may prevent stud from reaching its proper depth.)

d. Install new stud with special driver gauge until it bottoms on the head (Figure 4)

FIGURE 4



JOB SHEET #5

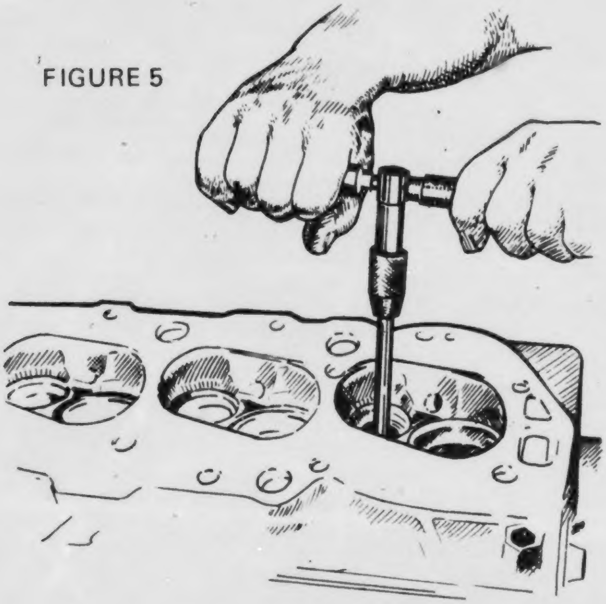
B. Repair worn valve guides

(NOTE: Excessively worn valve guides may be repaired by reaming the guide to an oversize and using oversize valve stems or by machining the cylinder head and installing replaceable guides. Both methods are recommended. The technician should consider the cost when making recommendations. An alternate method, which may be used but is less effective, is knurlizing the existing guide.)

1. Install the ream handle on the proper size ream for the valve stem that is to be used

2. Ream guides using caution to start the ream straight (Figure 5)

FIGURE 5



C. Recondition valve seats

(NOTE: Several different types of equipment are available for grinding valve seats. The recommendation of the equipment's manufacturer should be carefully followed to obtain proper results. Regardless of what type of equipment is used, however, it is essential that the valve guide bore is clean of carbon or dirt to insure proper centering of the pilot in the guide.)

1. Reface stones to obtain a smooth, true surface

2. Install pilot in valve guide

JOB SHEET #5

3. Place roughing stone or forming stone over pilot and clean up the valve seat

   (NOTE Use stone dressed to the specified angle.)

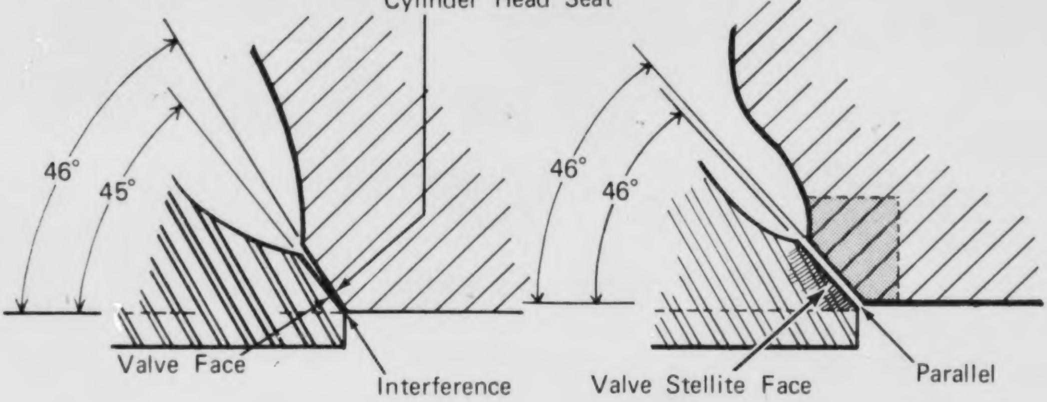
4. Remove roughing or forming stone from pilot

5. Place finishing stone and grind to remove just enough metal to provide a smooth finish (Figure 6)

6. Narrow down valve seat to the specified width

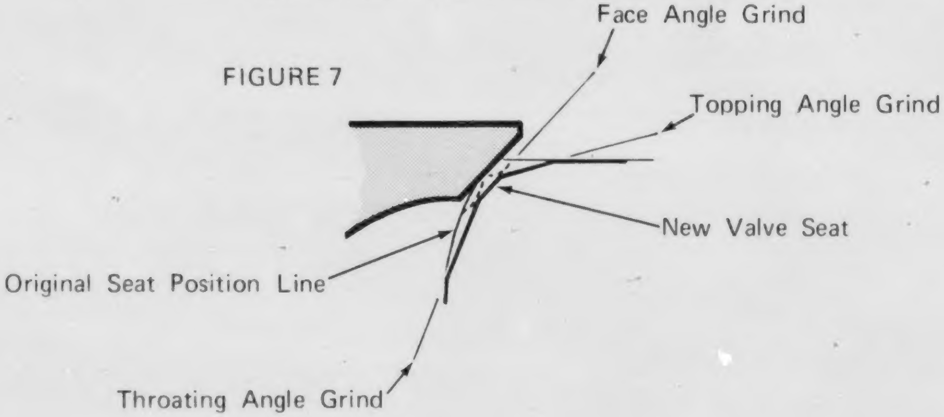
   (NOTE: This operation is done by grinding the port side with a 30° stone to lower seat and a 60° stone to raise seat. Use 30° and 60° stone for a 45° or 46° face angle and 15° and 60° stone for 30° or 29° face angle. See Figure 6.)

FIGURE 6


Cylinder Head Seat
46°
45°
46°
46°
Valve Face
Interference
Valve Stellite Face
Parallel

7. Adjust valve seat position so that the seat strikes the valve face slightly below the center of the face (Figure 7)

FIGURE 7


Face Angle Grind
Topping Angle Grind
New Valve Seat
Original Seat Position Line
Throating Angle Grind

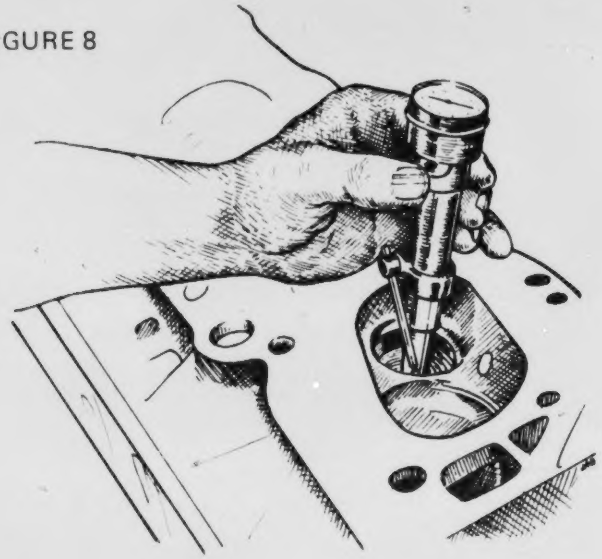
JOB SHEET #5

8. Remove the pilot from the head

9. Clean cylinder head carefully to remove all chips and grindings accumulated during the grinding operation

10. Measure valve seat roundness (Figure 8)

FIGURE 8



(NOTE: Valve seat must be rounded to within 0.002" [0.0508 mm] total indicator reading.)

D. Recondition valves

(NOTE: Valves that are pitted can be refaced to the proper angle, insuring correct relation between the head and stem. Replace valves if stems show excessive wear, if the heads are warped, or if margins have been ground too thin.)

1. Dress the valve refacing machine's grinding wheel to make sure it is smooth and true

2. Set chuck at angle specified for the valve

3. Clamp the valve stem in the chuck of the machine

4. Start the machine and move the valve head in line with the grinder wheel

JOB SHEET #5

5. Observe valve head rotation for excessive out-of-round

6. Turn on grinder coolant

7. Adjust coolant nozzle so that the valve head will have coolant running on it when grinding

8. Turn the feed screw until the valve head just contacts wheel

9. Move the valve head back and forth across the wheel while regulating the feed to maintain a light valve contact

   (CAUTION: Do not let the valve face go off the grinding wheel while they are in contact because this will rough up the valve face and groove the wheel.)

10. Continue grinding until the valve face is true and smooth all around the valve face

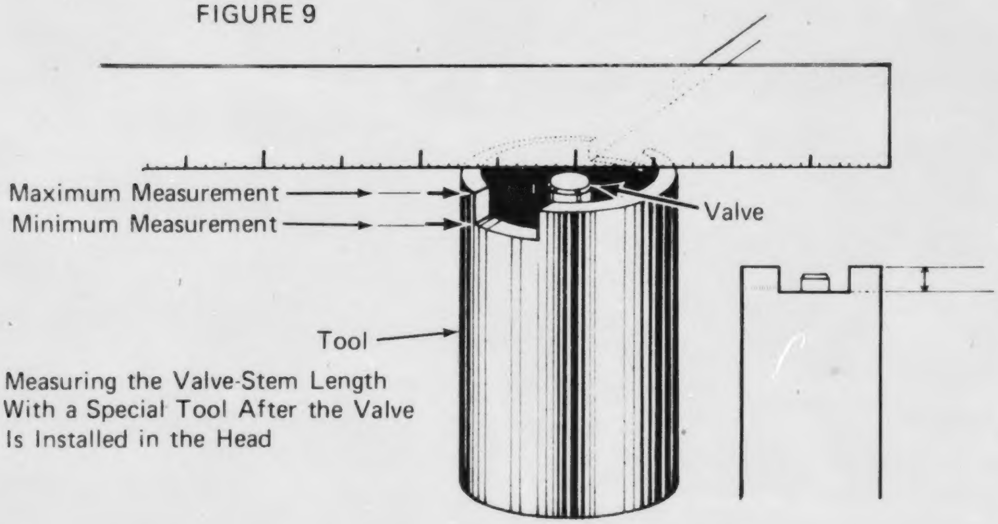
    (NOTE: If this makes the valve margin too thin, less than 1/16" [1.58 mm], the valve must be replaced.)

11. Remove the valve from the chuck

12. Place valve in V-block to resurface the end of the stem

    (NOTE: Before grinding valves on engines with nonadjustable rocker arms, place the valve in the cylinder head and measure the valve stem height so that the amount of resurfacing will maintain correct stem height. See Figure 9.)

FIGURE 9



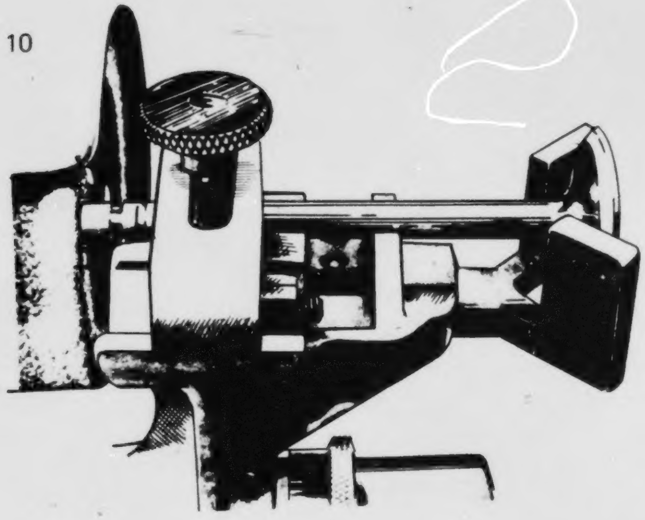
Measuring the Valve-Stem Length With a Special Tool After the Valve Is Installed in the Head

JOB SHEET #5

13. Feed valve squarely against the grinding wheel and remove only enough metal to remove pits from the stem end (Figure 10)

    (CAUTION: Only the extreme end of the valve stem is hardened to resist wear. Do not grind stems excessively. Some manufacturers recommend that valve stems not be resurfaced for any reason. If damaged, they must be replaced.)

FIGURE 10



14. Chamfer valve stem

15. Clean cylinder head and valves of all grinding particles

16. Make pencil marks about 1/4" (6 mm) apart across the valve face

17. Place the valve in the cylinder head and give it about half of a turn in each direction while exerting firm pressure on the valve head

18. Remove valve and check face carefully

    (NOTE: If all pencil marks have not been removed at the point of contact with the seat, it will be necessary to repeat the refacing operation and then recheck for proper seating.)

19. Grind and check the remaining valves in the same manner

JOB SHEET #5

E. Reassemble cylinder head

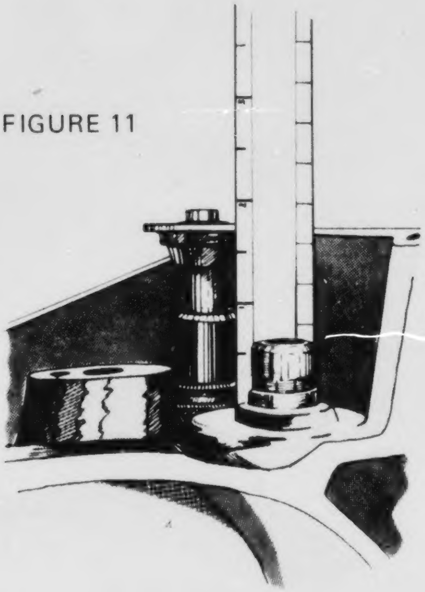
1. Lubricate valve stem

2. Insert a valve in the proper port

3. Check installed height of the valve springs by measuring from the top of the shim or spring seat to the top of the spring retainer (Figure 11)

   (NOTE: Adjust the shim thickness to correct the installed height of the spring to specifications.)

FIGURE 11

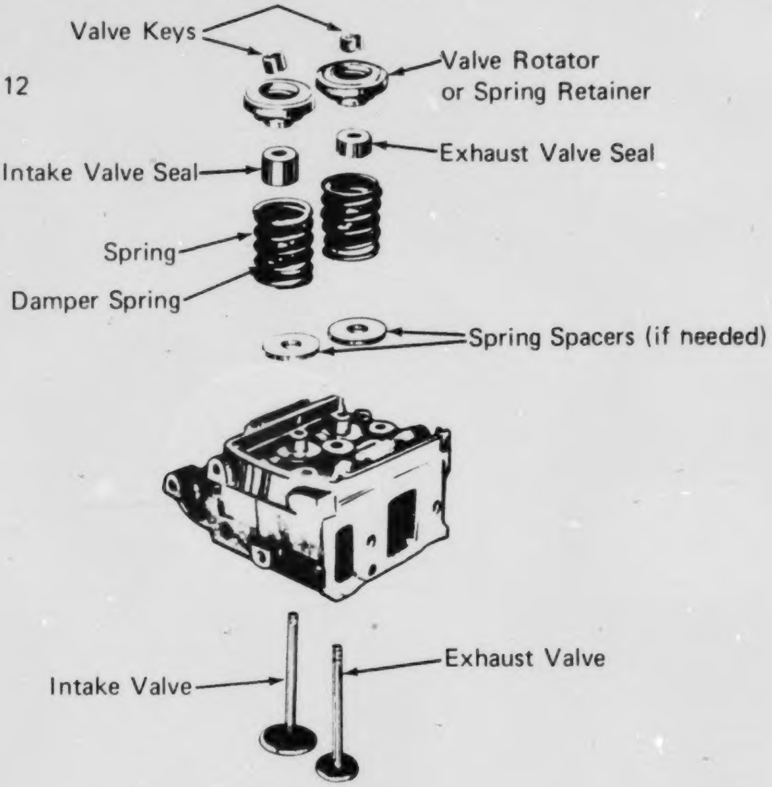


(CAUTION: At no time should the spring be shimmed to give an installed height under the minimum specified.)

JOB SHEET #5

4. Assemble valve parts in the proper order (Figure 12)

FIGURE 12


Valve Keys
Valve Rotator
or Spring Retainer
Exhaust Valve Seal
Intake Valve Seal
Spring
Damper Spring
Spring Spacers (if needed)
Exhaust Valve
Intake Valve

5. Compress spring with spring compressor

6. Install O-ring type seal, if used, in second groove of valve stem

   (NOTE: Be sure the seal is even and flat in the groove.)

7. Install the valve keepers and release the compressor tool, making sure the keepers seat properly in the upper grooves of the stem

8. Tap the valve stem end to seat valve spring keepers

VALVE TRAIN AND CYLINDER HEAD RECONDITIONING
UNIT IV

TEST

NAME ______________________________ SCORE ____________________

1. Match the terms on the right to the correct definitions.

_____a. Valve-operating mechanism of the engine

_____b. Shaft in the engine which operates the valves through a series of lobes

_____c. Engine with the valves in the cylinder head over the cylinder

_____d. Number of degrees of crankshaft rotation while the valve is open

_____e. That part of an engine that encloses the cylinder bores and contains the water jacket and sometimes the valves

_____f. Distance the valve moves from closed to full open

_____g. Camshaft that is located in the cylinder head or heads

_____h. Cylindrical part of the engine that rests on a cam of the camshaft so that the valve is opened as the cam rotates

_____i. Looseness designed into the valve train so the valve will seat properly

1. Cam duration
2. Valve train
3. Camshaft
4. Overhead camshaft
5. Cam lift
6. Cylinder head
7. I-head engine
8. Valve lifter
9. Valve lash or clearance adjustment

2. State the purpose of the valve train.

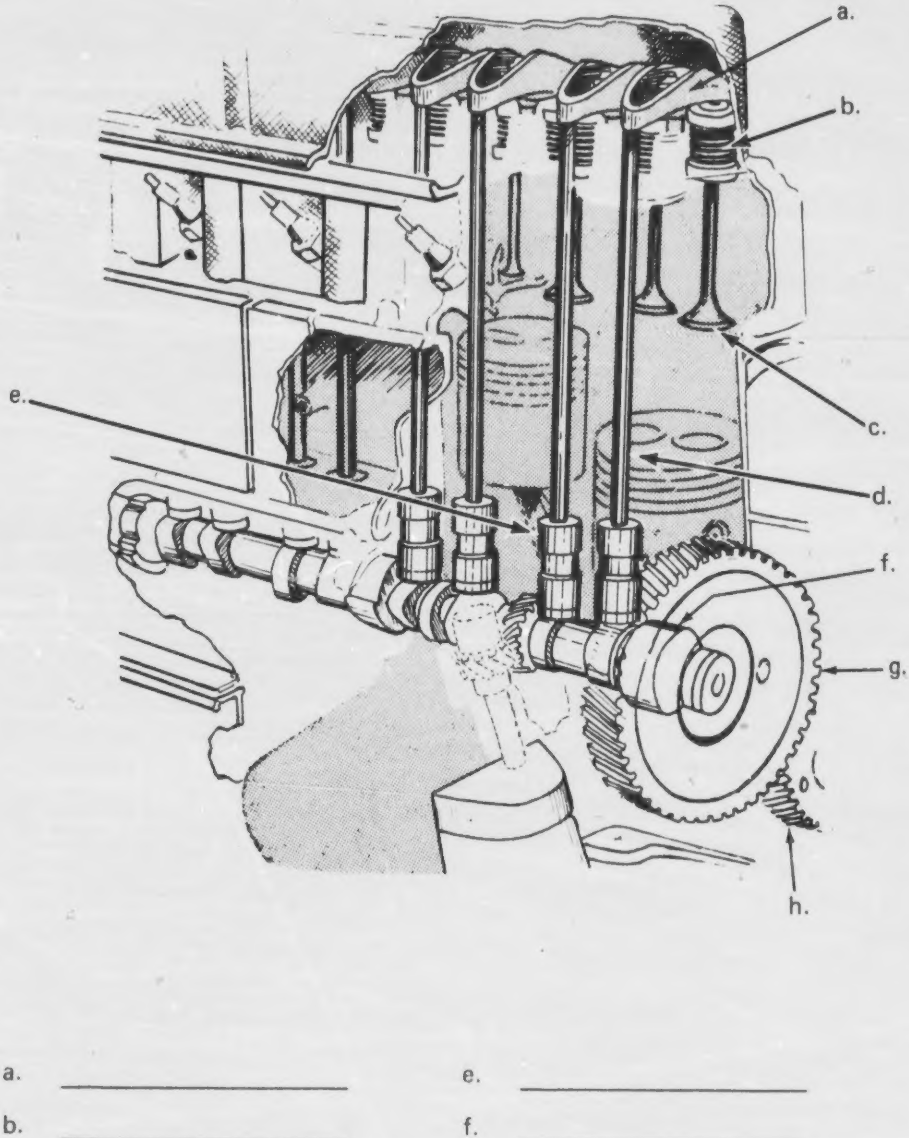
_______ ____

____

____

____

3. Identify the parts of the valve train by writing the correct names in the blanks provided.



a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

g. ____________________

h. ____________________

4. Match the valve train parts on the right to their correct functions.

______a. Changes the direction of motion in the valve train and pushes the valve off of its seat

______b. Operates the valve lifters by rotating cam lobes against the lifters

______c. Drives the cam gear

______d. Opens and closes the intake and exhaust ports connected to the cylinder

______e. Transmits motion from the lifter to the rocker arm

______f. Turns the camshaft and is used in timing the camshaft to the crankshaft

______g. Forces the valve to close

______h. Rides along the cam lobe to change rotating motion to reciprocal motion

1. Valve
2. Valve spring
3. Rocker arm
4. Push rod
5. Lifter (tappet)
6. Camshaft
7. Cam gear
8. Crankshaft gear

5. Select from the list the correct camshaft locations.

______a. In cylinder block

______b. In crankcase

______c. In cylinder head

______d. In combustion chamber

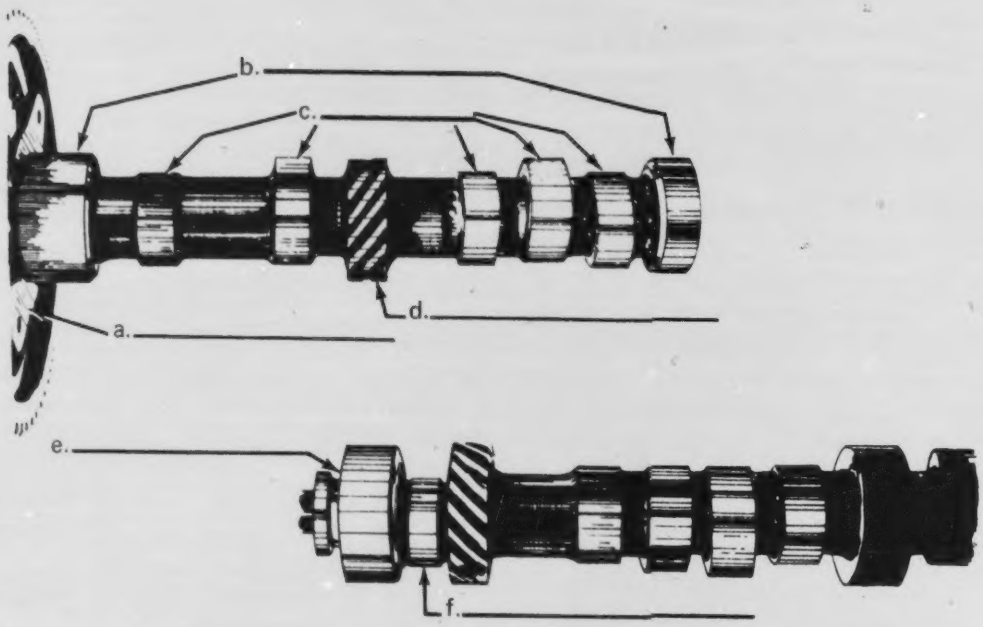
6. List the three methods of driving the camshaft.

a. ______________________________

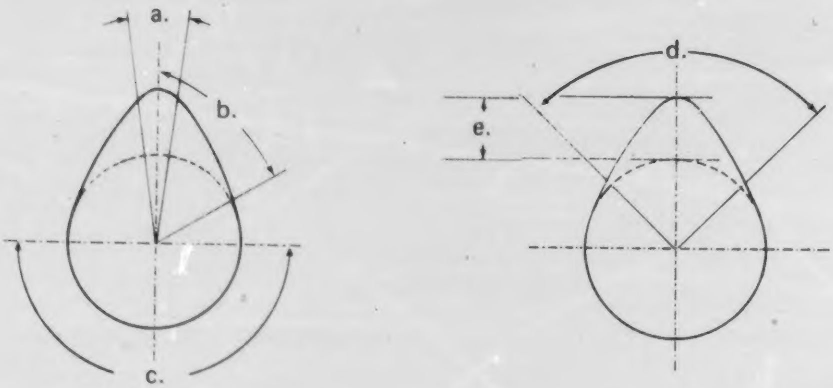
b. ______________________________

c. ______________________________

7. Identify the parts of the camshaft.



8. Identify the parts of the cam lobe.



a. ________________

b. ________________

c. ________________

d. ________________

e. ________________

9. List two types of valve lifters.

a. ______________________________

b. ______________________________

10. Identify the parts of the hydraulic valve lifter.

a. __________

b. __________

c. __________

d. __________

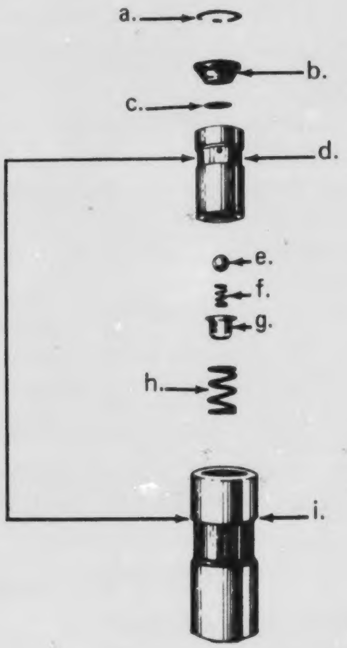
e. __________

f. __________

g. __________

h. __________

i. __________



11. Discuss the operation of a hydraulic valve lifter.

____

____

____

____

____

____

____

____

____

____

12. Identify the parts of the valve in the following illustration by writing the correct names in the blanks provided.

a. ____________

b. ____________

c. ____________

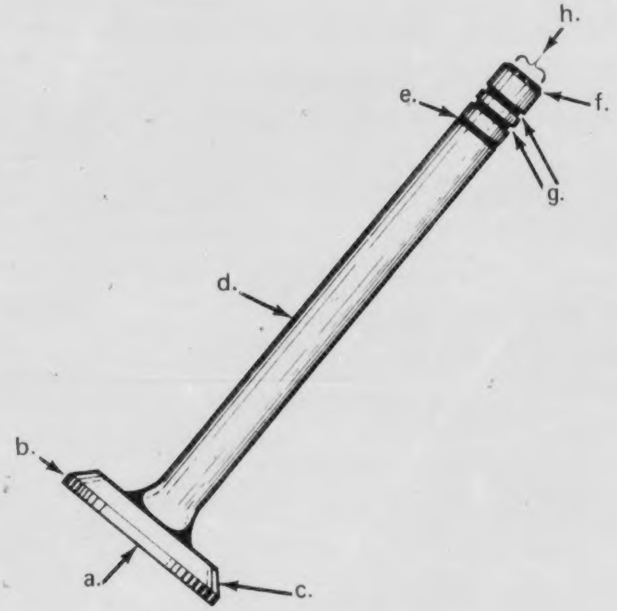
d. ____________

e. ____________

f. ____________

g. ____________

h. ____________



13. Identify the parts of the following valve assembly.

a. ____________

b. ____________

c. ____________

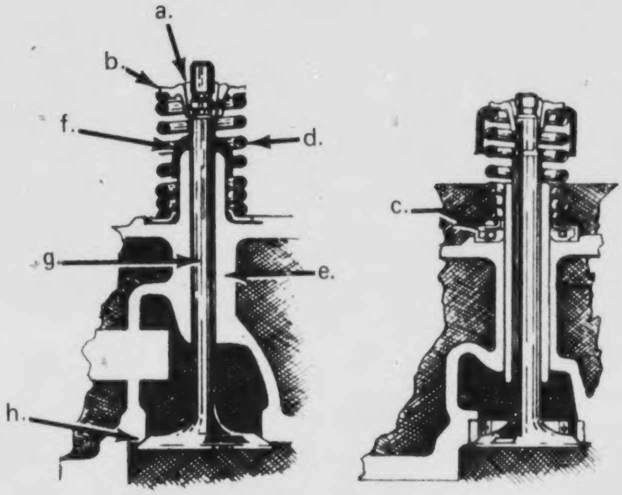
d. ____________

e. ____________

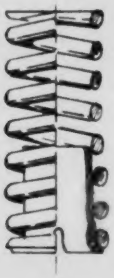
f. ____________

g. ____________

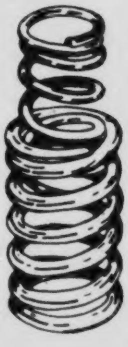
h. ____________



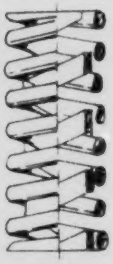
14. Identify the following types of valve springs and dampering devices by writing the correct names in the blanks provided.



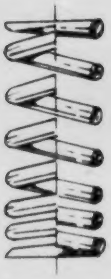
a. ____________________



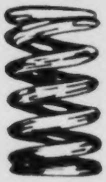
b. ____________________



c. ____________________

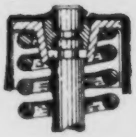


d. ____________________

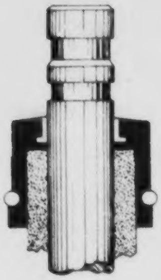


e. ____________________

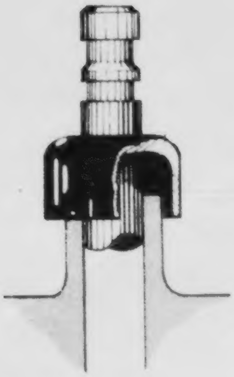
15. Identify the types of valve stem seals.



a. ____________________

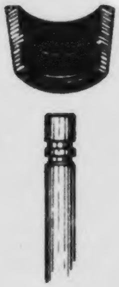


b. ____________________

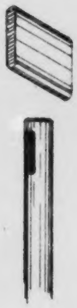


c. ____________________

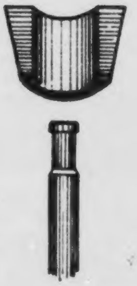
16. Identify the following types of valve spring keepers by writing the correct names in the blanks provided.



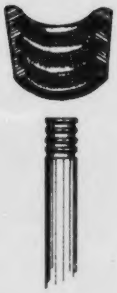
a. ____________________



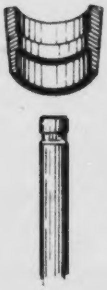
b. ____________________



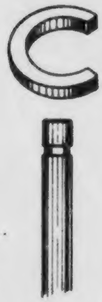
c. ____________________



d. ____________________



e. ____________________



f. ____________________

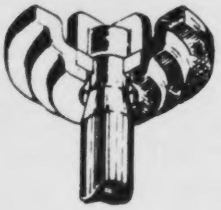
17. State the purpose of a valve spring spacer.

____

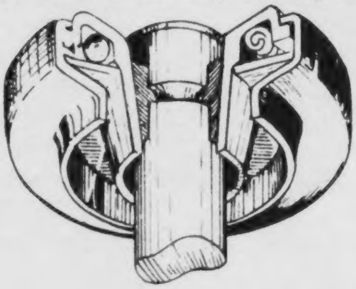
____

____

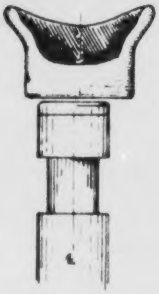
18. Identify the following types of valve rotators by writing the correct names in the blanks provided.



a. ____________________



b. ____________________



c. ____________________

19. State the purpose of a valve rotator.

____

____

____

____

20. List two reasons a valve must seat properly.

a. ____

____

b. ____

____

21. Select from the list below the major causes of valve burning.

______a. Weak or cocked valve springs

______b. Insufficient valve tappet clearance

______c. Carbon deposits in crankcase

______d. Valve not seating properly

______e. Worn valve guides

______f. Clogged water jacket or distribution tube causing localized hot spots

______g. Engine overheating

______h. Insufficient air in air-fuel mixture

______i. Carbon deposits in the combustion chamber

______j. Worn cam lobes

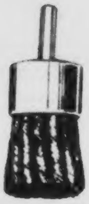
______k. Exhaust heat riser valve stuck in closed position

______l. Warped valve seat from improper torqueing of cylinder head

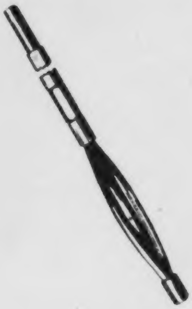
______m. Extremely lean air-fuel mixture

______n. Preignition and detonation

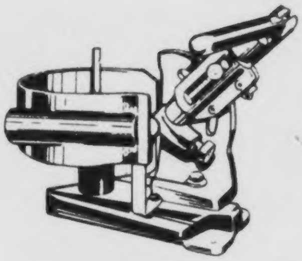
22. Identify the following tools used for valve reconditioning.



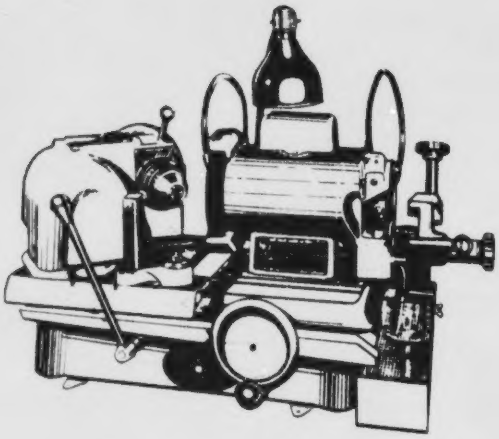
a. ____________________



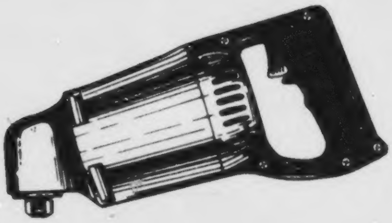
b. ____________________



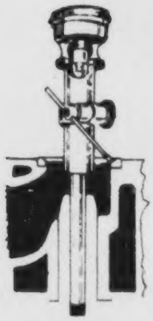
c. ____________________



d. ____________________



e. ____________________



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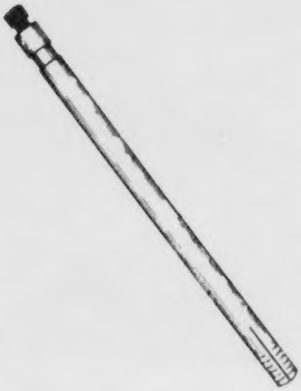

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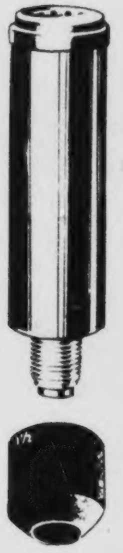
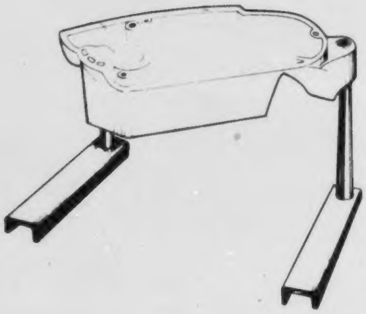
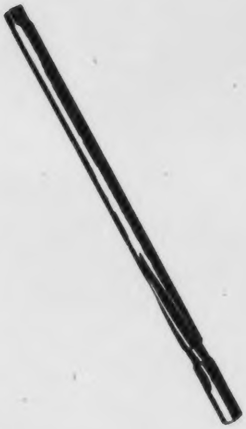
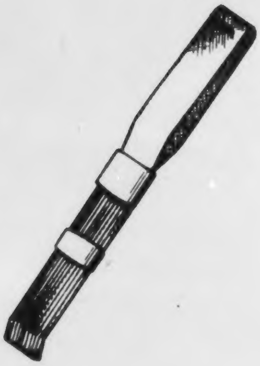


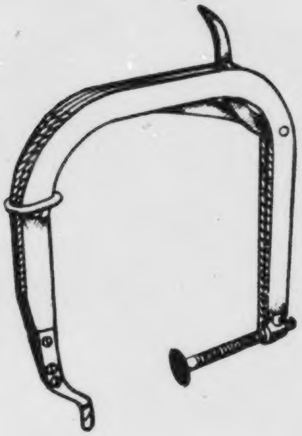


h. ________________________ i. ________________________

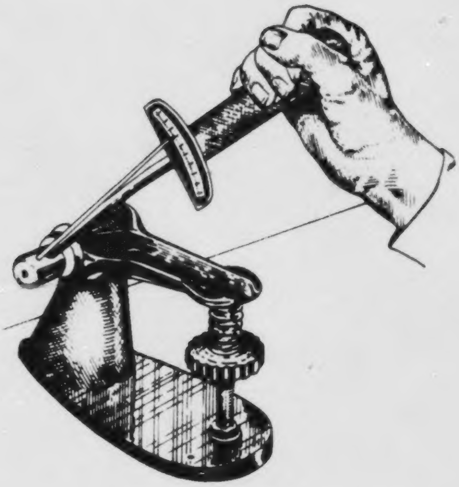




j. ________________________ k. ________________________



l. ____________________



m. ____________________

23. Demonstrate the ability to:

a. Inspect timing gears and measure timing chain for stretch and camshaft end play.

b. Inspect camshaft.

c. Clean and inspect hydraulic lifters.

d. Disassemble, clean, and inspect a cylinder head assembly.

e. Recondition cylinder head.

(NOTE: If these activities have not been accomplished prior to the test, ask the instructor when they should be completed.)

VALVE TRAIN AND CYLINDER HEAD RECONDITIONING
UNIT IV

ANSWERS TO TEST

1. a. 2
   b. 3
   c. 7
   d. 1
   e. 6
   f. 5
   g. 4
   h. 8
   i. 9

2. To operate the intake and exhaust valves with piston movement which will cause the four-stroke cycle to occur

3. a. Rocker arm
   b. Valve spring
   c. Valve
   d. Push rod
   e. Valve lifter or tappet
   f. Camshaft
   g. Cam gear
   h. Crankshaft gear

4. a. 3
   b. 6
   c. 8
   d. 1
   e. 4
   f. 7
   g. 2
   h. 5

5. a, c

6. a. Gear
   b. Chain
   c. Belt

7. a. Retainer plate
   b. Bearing journal
   c. Cam lobes
   d. Accessory drive gear
   e. Thrust face
   f. Fuel pump eccentric
8. a. Nose
   b. Ramp
   c. Heel
   d. Valve duration
   e. Valve lift
9. a. Solid
   b. Hydraulic
10. a. Lock ring
    b. Push rod cup
    c. Metering disc
    d. Plunger
    e. Ball
    f. Ball spring
    g. Ball retainer
    h. Plunger spring
    i. Body
11. Discussion should include:
    a. Engine oil is fed into the lifter through holes in the undercut area of the lifter body
    b. Oil under pressure inside the plunger pushes the check valve open and fills the area between the bottom of the plunger and the body, causing them to expand and to keep zero clearance in the valve linkage when the lifter is on the heel portion of the cam lobe

c. Oil is trapped between the plunger and body to maintain plunger position in the lifter body as the lifter rides up the cam lobe

12. a. Head

b. Margin

c. Face

d. Stem

e. Seal groove

f. Chamfer

g. Lock grooves

h. Lift area

13. a. Keepers

b. Spring retainer

c. Rotator

d. Spring

e. Valve guide

f. Oil seal

g. Valve

h. Valve seat

14. a. Friction damper tube

b. Standard spring with inner assist spring

c. Friction damper spring

d. Variable rate spring

e. Standard spring

15. a. O-ring

b. Teflon cup

c. Cup or umbrella

16. a. Two-groove conical

b. Pin type

c. Plain conical

d. Four-groove conical

e. Single-groove conical

f. Horseshoe

17. To maintain correct valve spring installed height

18. a. Free type

b. Positive type

c. Off-center type

19. To rotate the valve a small amount each time the valve opens

20. a. To make an airtight seal on the combustion chamber

b. To enable the valve to cool

21. a, b, d, e, f, g, i, k, l, m, n

22. a. Carbon brush

b. Guide cleaner

c. Wheel dressing tool (seat grinding)

d. Valve grinding machine

e. Drive motor (seat grinding)

f. Valve seat indicator

g. Seat grinding pilot

h. Wheel holder (seat grinding)

i. Cylinder head stand

j. Guide reamer

k. Carbon scraper

l. Spring compressor

m. Valve spring tension gauge

22. Performance skills evaluated to the satisfaction of the instructor

ENGINE CRANKSHAFT, BEARINGS, AND OIL PUMP
UNIT V

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify crankshaft problems, inspect an oil pump, make necessary measurements to evaluate crankshaft and bearing conditions, and make necessary repairs. This knowledge will be evidenced through demonstration and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with the crankshaft, bearings, and oil pump to the correct definitions.
2. Write the purpose of the crankshaft.
3. Identify the parts of a crankshaft.
4. List methods used to manufacture crankshafts.
5. Identify types of bearings used on the cam and crankshaft.
6. List the layers of materials used to make insert bearings.
7. Distinguish between bearing spread and bearing crush.
8. Match bearing requirements to the correct definitions.
9. Match the causes of bearing failure to the correct illustration of a damaged bearing.
10. Discuss the action of lubrication oil in an insert type bearing.
11. Distinguish between the purposes of the torsional vibration damper and flywheel.
12. List types of rear main bearing oil seals.
13. Identify types of oil pumps.
14. Identify parts of an oil pump.
15. Select from a list conditions that could cause low oil pressure.

16. Demonstrate the ability to:
    - a. Check main bearing bore alignment.
    - b. Measure and inspect a crankshaft.
    - c. Fit a crankshaft bearing with plastigauge.
    - d. Install a rear main bearing seal (crankshaft removed).
    - e. Disassemble, clean, and inspect an oil pump.

ENGINE CRANKSHAFT, BEARINGS, AND OIL PUMP
UNIT V

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss the procedures outlined on the job sheets.

   G. Give test.

II. Unit references:

   A. Ellinger, Herbert E. *Automechanics.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1972.

   B. Crouse, William H. *Automotive Mechanics.* 7th ed. New York: McGraw-Hill Book Co., 1975.

   C. Crouse, William H. *Automotive Engine Design.* New York: McGraw-Hill Book Co., 1970.

   D. *Chevrolet Service Manual.* Detroit: Chevrolet Motor Div./General Motors Corp., 1977.

   E. *Chrysler, Plymouth, Dodge Chassis Service Manual.* Detroit: Chrysler Corp., 1976.

   F. *Ford Service Manual.* Dearborn, Michigan: Ford Motor Co., 1975-76.

ENGINE CRANKSHAFT, BEARINGS, AND OIL PUMP
UNIT V

INFORMATION SHEET

I. Terms and definitions

A. Bearing--Surface that supports a moving load with minimum drag

B. Bearing tang--Notch or lip on a bearing shell used to correctly locate the bearing during assembly and operation

C. Bore--Diameter of a hole

Example: Cylinder or crankshaft bore in block

D. Bushing--Spacing device; usually a sleeve with a bearing surface on the inside

E. Cast--Part made by pouring melted metal into a mold where it cools to the shape of the mold

F. Forging--Process of hammering or compressing a red hot metal part to form it into the desired shape

G. Crankpin--That portion of the crankshaft upon which the connecting rod fastens

H. Bearing crush--Slight distortion of the bearing shell that holds it in place as the engine operates

I. Idler gear--Rotating gear that does not transfer a load

J. Journal--Surface on which a bearing operates

K. Pilot bearing--Bearing in the back of the crankshaft that supports the front of the clutch shaft

L. Plastigauge--Small-sized plastic thread for measuring clearances by the amount it is smashed between the parts

(NOTE: Plastigauge is used to measure clearances between bearing and journals.)

M. Torsional vibration damper--Round, weighted device attached to the front of the crankshaft to minimize the torsional (twisting) vibration of the shaft

N. Bearing spread--Split-sleeve bearings have a slightly larger arc than the bearing housing bore

II. Purpose of the crankshaft--To change the reciprocating motion of the pistons to a rotating motion

INFORMATION SHEET

III. Parts of the crankshaft (Transparency 1)

  A. Main bearing journal

  B. Crankpin (connecting rod journal)

  C. Crankpin fillet

  D. Crank cheek

  E. Crank web

  F. Oil passages

  G. Oil slinger

  H. Flywheel flange

  I. Crankshaft gear (cam drive gear mounting area)

  J. Pulley and damper mounting area

  K. Counterweight

  L. Thrust bearing area

IV. Methods used to manufacture crankshafts

  (NOTE: Crankshafts are made of heat-treated alloy steel.)

  A. Cast

  B. Forge

V. Types of bearings used on the cam and crankshaft (Transparency 2)

  A. Split sleeve type friction bearing

    Examples: Rod and main bearing

  B. Sleeve type friction bearing

    Examples: Cam bearings

  (NOTE: These are precision-fit bearings.)

INFORMATION SHEET

VI. Construction of an insert bearing (Transparency 3)

A. Steel back

B. Inner layer of bearing alloy

C. Thin overlay of a soft bearing alloy

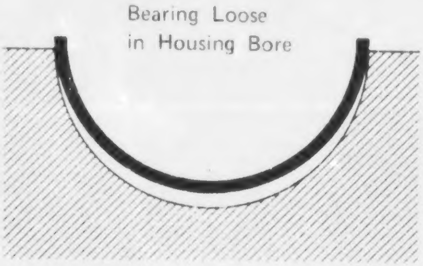
D. Barrier plating

(NOTE: The bearing alloy may consist of such metals as lead, copper, tin, antimony, mercury, cadmium, aluminum, and silver.)

VII. Bearing spread and crush

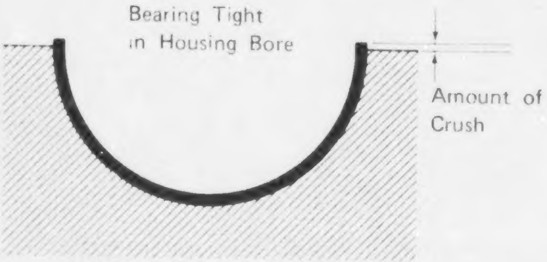
A. Bearing spread

(NOTE: Bearing spread is from 0.005" to 0.020" [0.127 mm to 0.508 mm] wider than the housing bore. This spread helps to hold the bearing in place during installation.)



B. Bearing crush

(NOTE: Bearing crush holds the bearing in place and keeps the bearing from turning when the engine runs. Crush must exert a force of at least 12,000 psi [82,800 kPa] stress between the bearing and housing bore to hold it in place.)



INFORMATION SHEET

VIII. Bearing requirements

A. Load-carrying capacity--Ability to support the severe centrifugal and combustion forces in the engine

B. Embeddability--Ability to permit foreign particles to become compressed into the soft bearing surface to protect the smooth crankshaft

C. Fatigue resistance--Resistance to severe pressures and bending without failure

D. Conformability--Ability of the soft bearing surface to change to variations in shaft alignment and journal shape

E. Corrosion resistance--Ability to resist the corrosive effect of combustion by-products

F. Wear rate--Hard and tough enough to maintain a long service life

IX. Causes of bearing failure (Transparency 4)

A. Lack of oil

B. Fatigue failure

C. Scratched by dirt

D. Tapered journal

E. Radius ride

F. Improper seating

X. Action of lubricating oil in an insert bearing (Transparency 5)--Keeps the bearing and rotating shaft journal separated by a film of oil so there is no actual metal-to-metal contact

XI. Purposes of torsional vibration damper and flywheel

A. Torsional vibration damper (also called harmonic balancer)--Opposes crankshaft torsional vibration or the twist-untwist action of the crankshaft caused by the cylinder firing impulse

(NOTE: The vibration damper is also part of the crankshaft drive pulley assembly.)

B. Flywheel--Evens out the power surges from power stroke to power stroke

(NOTE: The flywheel also serves as part of the clutch and engine cranking system. The torque converter on automatic transmissions acts as a flywheel.)

INFORMATION SHEET

XII. Types of rear main bearing oil seals (Transparency 6)

- A. Lip
- B. Rope

XIII. Types of oil pumps (Transparency 7)

- A. Rotor
- B. Gear

XIV. Parts of an oil pump (Transparency 8)

- A. Extension shaft

  (NOTE: It is not used on some models.)
- B. Drive gear and shaft
- C. Idler gear
- D. Pump body
- E. Pump cover

  (NOTE: Some models require a gasket between pump cover and pump body.)
- F. Pressure regulator valve
- G. Pressure regulator spring
- H. Washer
- I. Retaining pin
- J. Screws
- K Pickup screen and pipe

XV. Conditions that could lower oil pressure

- A. Low oil level
- B. Excessive main bearing clearance
- C. Excessive rod bearing clearance
- D. Excessive camshaft bearing clearance

INFORMATION SHEET

E. Worn oil pump

F. Air leak in pickup screen and pipe

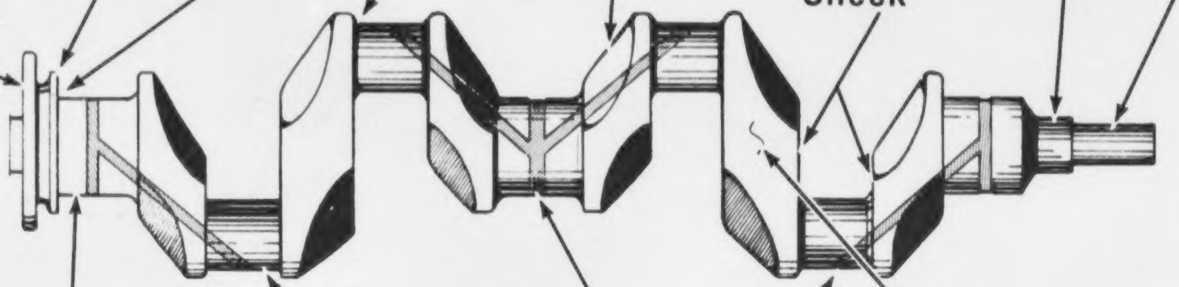
G. Leaks in oil passageways in cylinder block

H. Improper lubricating oil viscosity

I. Broken oil pressure regulator spring

(NOTE: These are the usual conditions. Other conditions may be added by your instructor.)

Parts of the Crankshaft



Crankshaft Gear (Cam Drive Gear Mounting Area)

Thrust Bearing Area

Crankpin Fillet

Crank Web

Crank Cheek

Pulley and Damper Mounting Area

Oil Slinger

Flywheel Flange

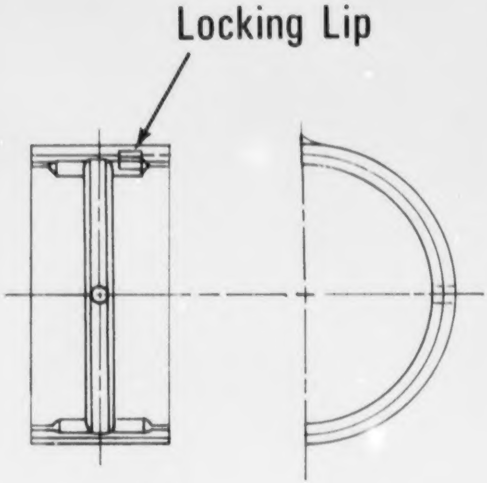
Main Bearing Journal

Crankpin (Connecting Rod Journal)

Oil Passages

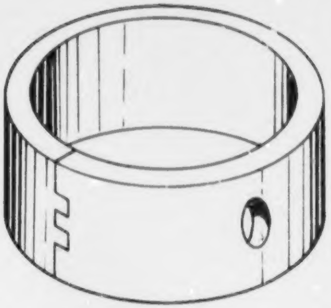
Counterweight

Types of Bearings Used on Cam and Crankshaft



Split Sleeve Type

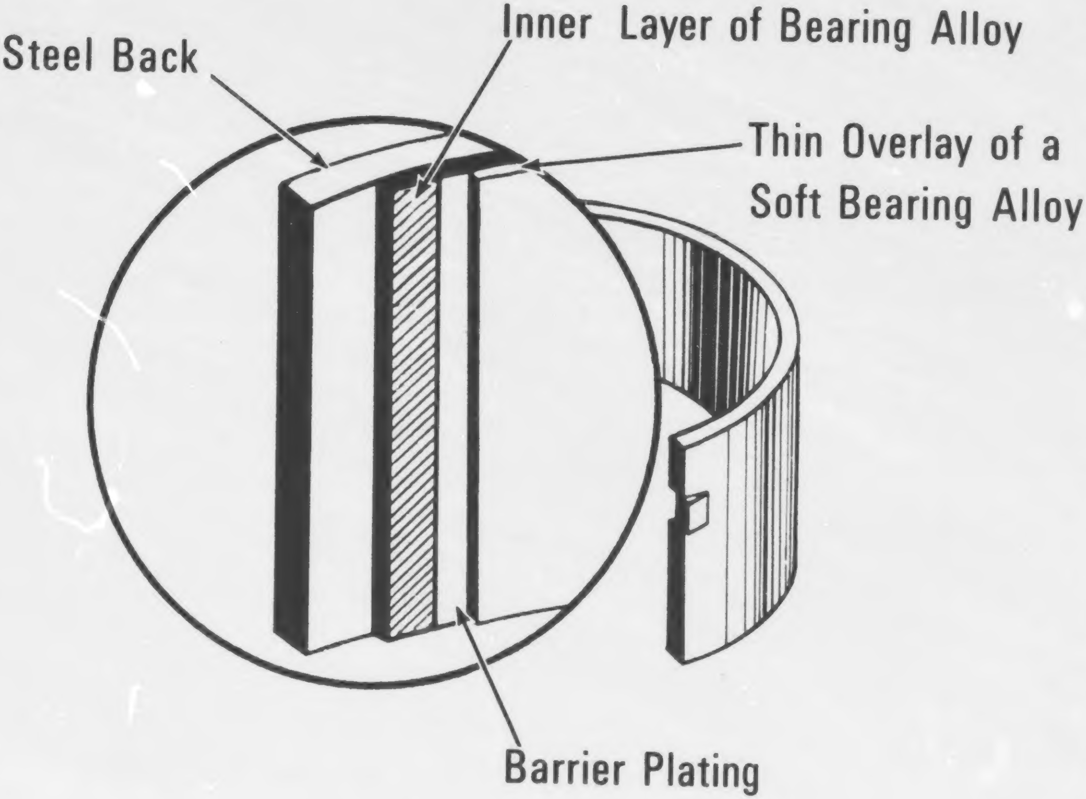
Used for Rod and Main Bearings



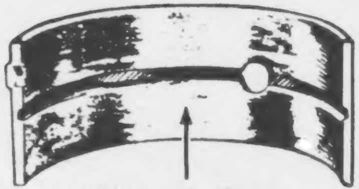
Sleeve Type

Used for Cam Bearings

Construction of an Insert Bearing

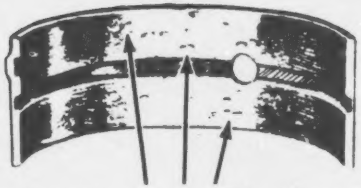

Steel Back
Inner Layer of Bearing Alloy
Thin Overlay of a Soft Bearing Alloy
Barrier Plating

Types of Bearing Failure



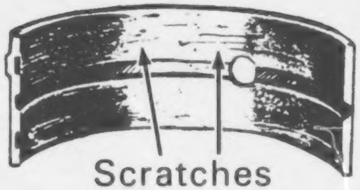
Wiped Out

Lack of Oil



Craters or Pockets

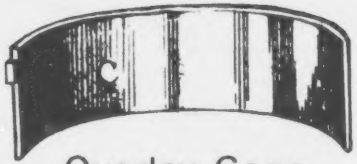
Fatigue Failure



Scratches

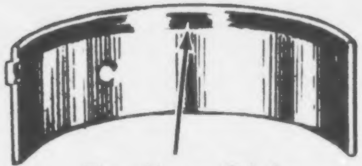
Dirt Imbedded
Into Bearing Material

Scratched by Dirt



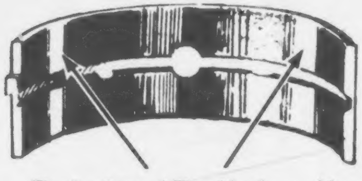
Overlay Gone
From Entire Surface

Tapered Journal



Radius Ride

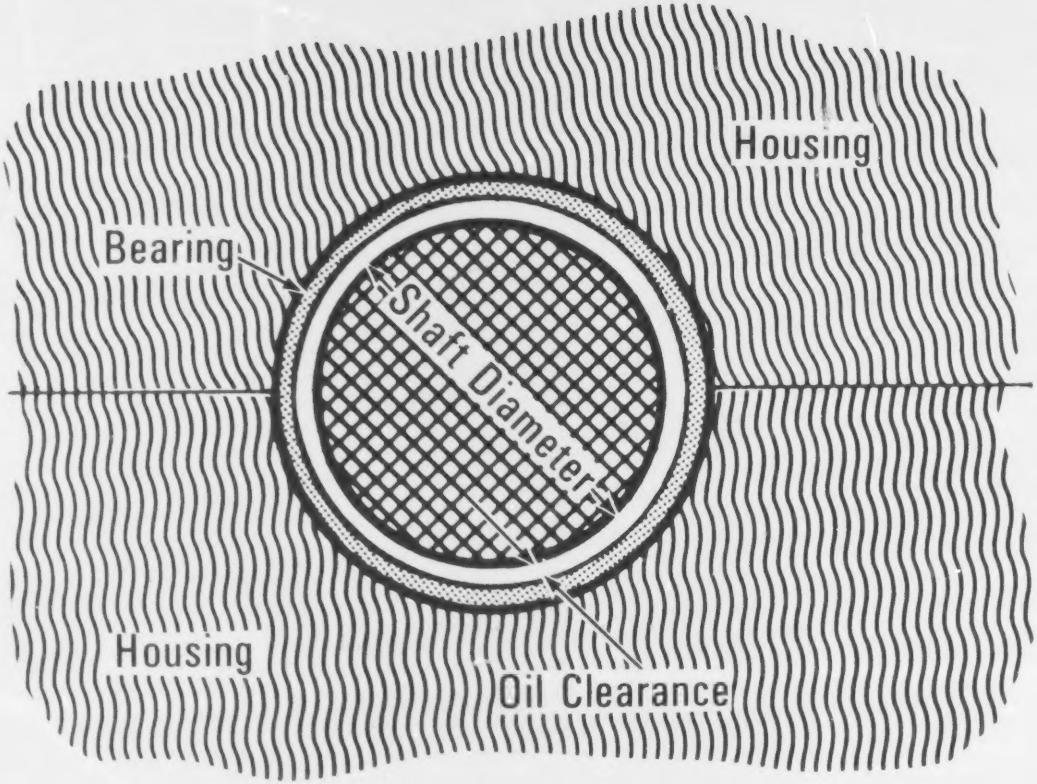
Radius Ride



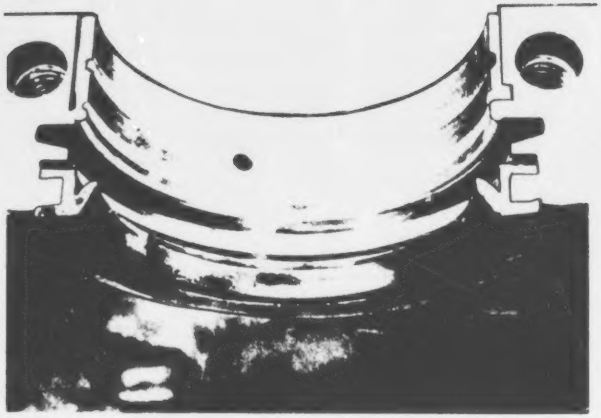
Bright (Polished)
Sections

Improper Seating

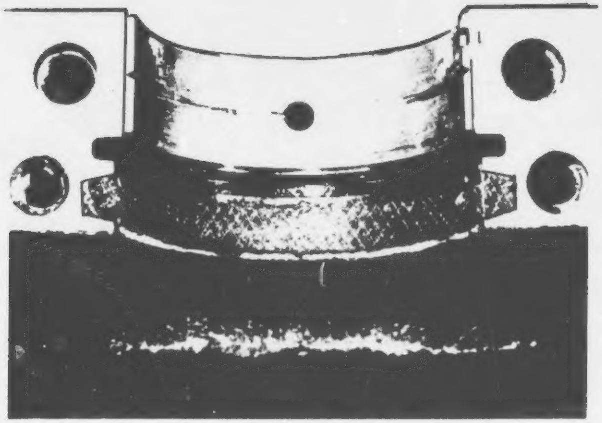
Lubricating Oil Action in an Insert Bearing


Housing
Bearing
Shaft Diameter
Housing
Oil Clearance

Types of Rear Main Bearing Seals

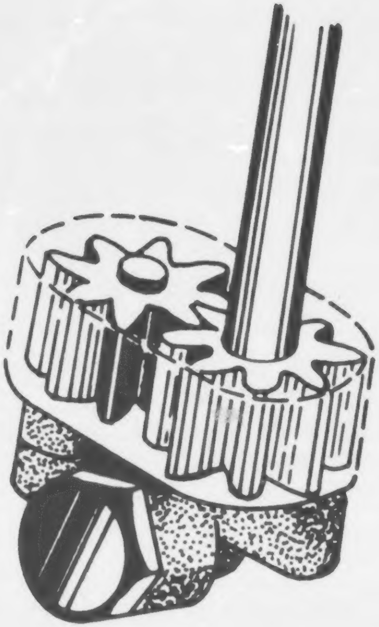


Lip Type Seal

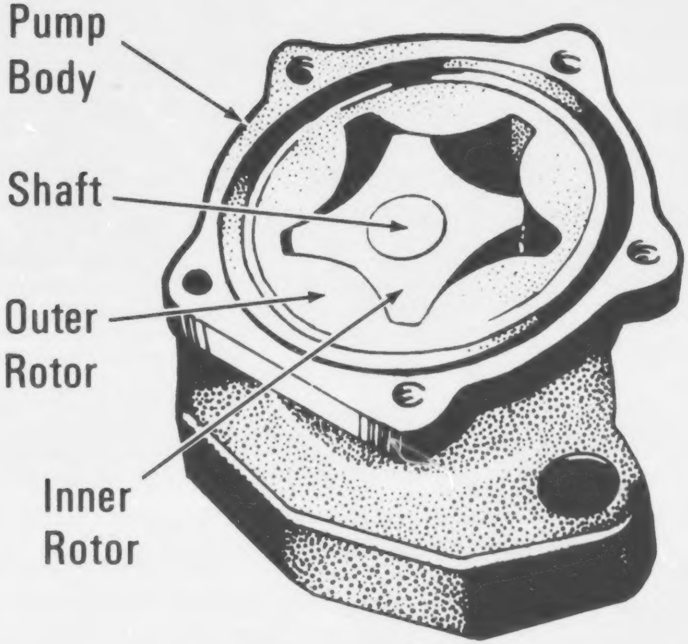


Rope Type Seal

Types of Oil Pumps

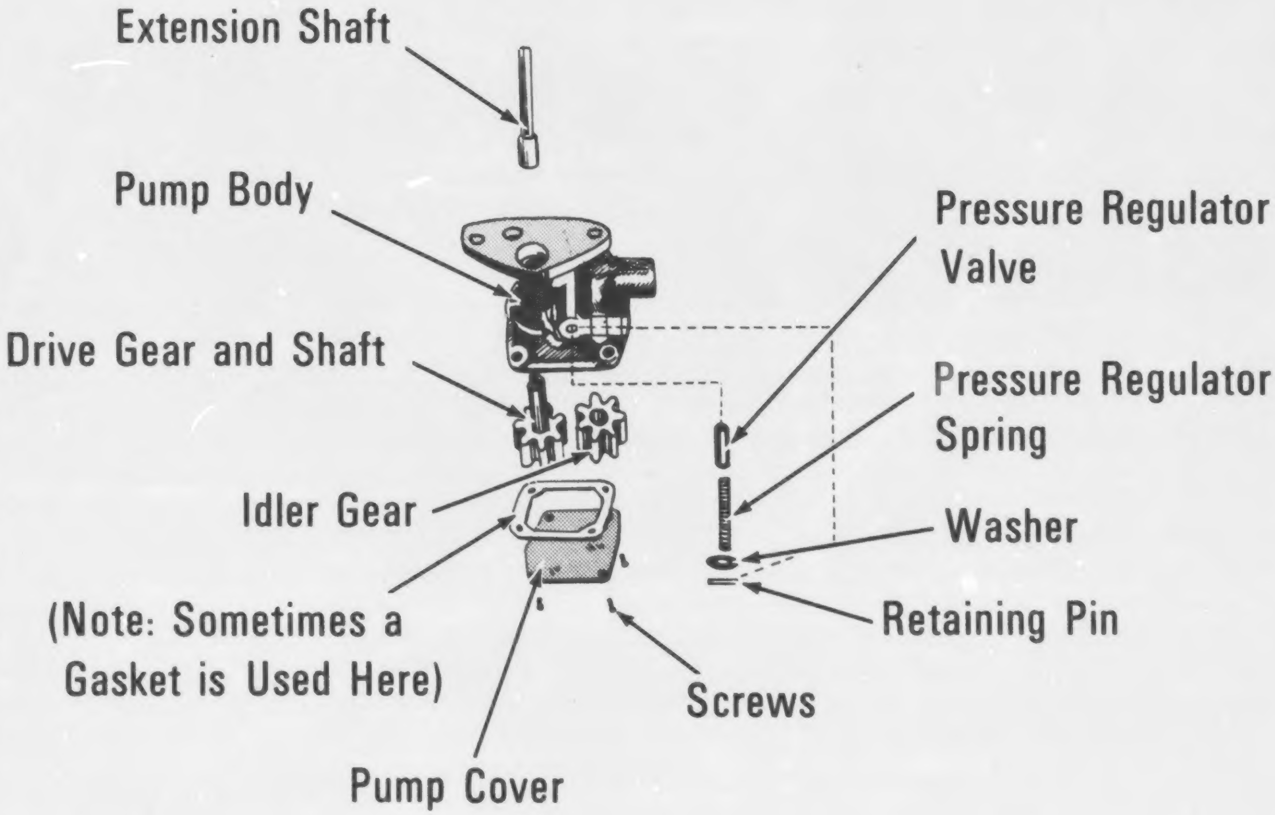


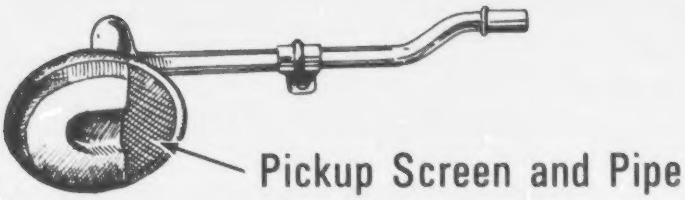
Gear


Pump Body
Shaft
Outer Rotor
Inner Rotor

Rotor

Parts of an Oil Pump


Extension Shaft
Pump Body
Pressure Regulator Valve
Drive Gear and Shaft
Pressure Regulator Spring
Idler Gear
Washer
(Note: Sometimes a Gasket is Used Here)
Retaining Pin
Screws
Pump Cover


Pickup Screen and Pipe

ENGINE CRANKSHAFT, BEARINGS, AND OIL PUMP
UNIT V

JOB SHEET #1--CHECK MAIN BEARING BORE ALIGNMENT

I. Tools and equipment

A. Straightedge

(NOTE: The straightedge should be as long as the cylinder block.)

B. Feeler gauge set

C. Clean shop towels

D. Engine oil

II. Procedure

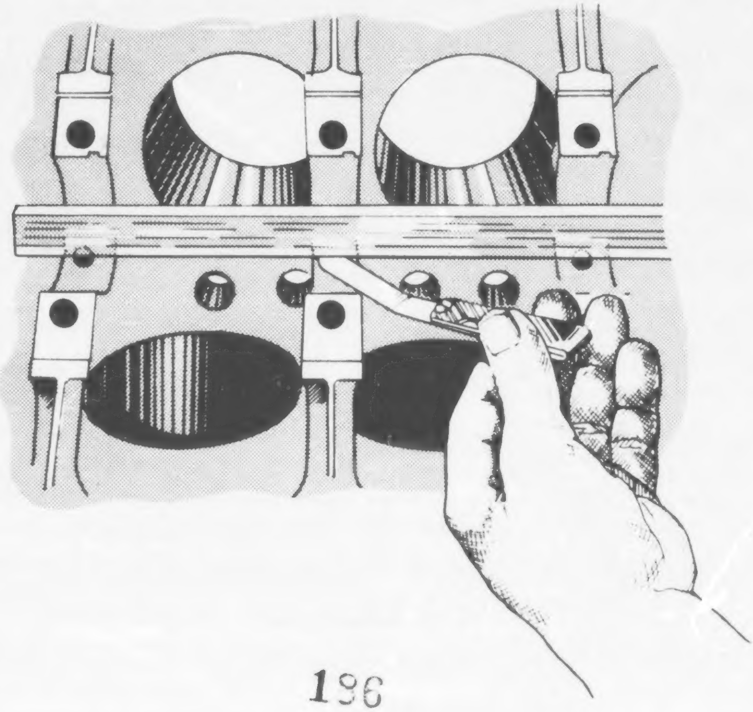
(NOTE: There are two methods of checking the main bearing bores for warpage. One method is to install a special, properly ground arbor, 0.001" [0.0254 mm] smaller than the bearing bore, in place of the crankshaft. If the arbor will turn with a 12" [30 cm] crank, the block is not warped. The other method, which does not require a special arbor, will be described in this job sheet.)

A. Remove crankshaft, upper main bearing halves, and rear main bearing seal if not already accomplished

B. Clean the main bearing bore and cap bosses thoroughly and air dry

C. Place the straightedge at the bottom of the main bearing bore (Figure 1)

FIGURE 1

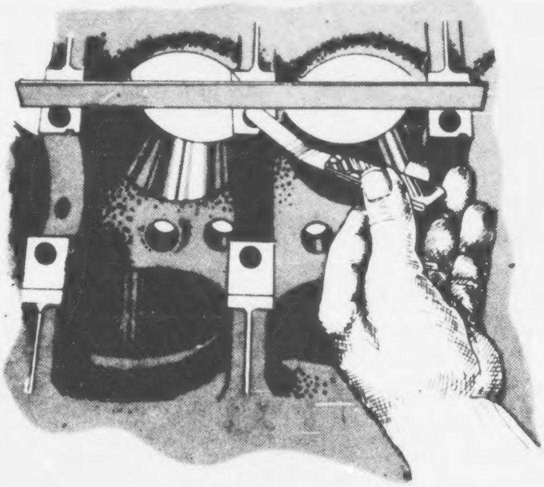


JOB SHEET #1

D. Check clearance between each bearing bore surface and straightedge

E. Place straightedge on main bearing cap bosses (Figure 2)

FIGURE 2



F. Check clearance between straightedge and bosses

(NOTE: Clearance between the surface and straightedge should not exceed one-half the allowable bearing clearance. If the clearance is greater than one-half the allowable clearance, the block will have to be remachined or discarded.)

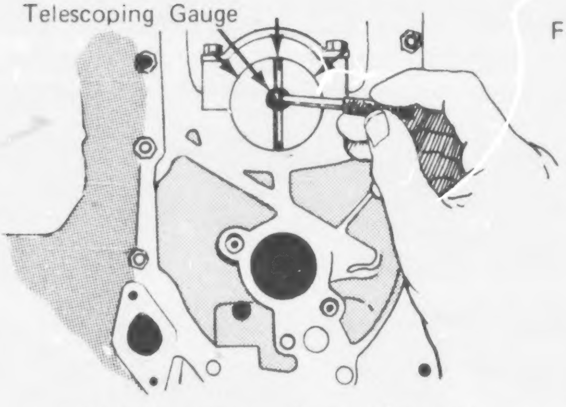
G. Check bearing bore for out-of-round

1. Install main bearing cup and torque to specifications

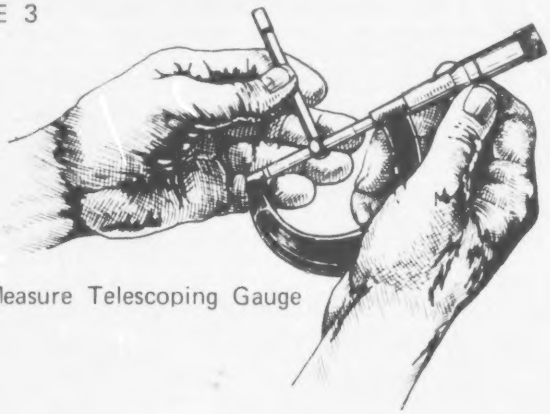
   (NOTE: Leave the bearing inserts out when checking bore out-of-round.)

2. Measure the bearing bore at three locations (Figure 3)

FIGURE 3



Measure Bore in Three Locations



Measure Telescoping Gauge

JOB SHEET #1

3. Compare the three measurements to obtain bore out-of-round

   (NOTE: Check manufacturers for allowable bore out-of-round. If out-of-round exceeds allowable limits, the block bore will have to be LINE bored by a machinist to correct the condition.)

ENGINE CRANKSHAFT, BEARINGS, AND OIL PUMP
UNIT V

JOB SHEET #2--MEASURE AND INSPECT A CRANKSHAFT

I. Tools and equipment

   A. Micrometer, 0 - 3" (0 - 76 mm) range

   B. Dial indicator

   C. Feeler gauge

   D. V-blocks, 2

   E. Clean shop towel

   F. Engine oil, 10 W

II. Procedure

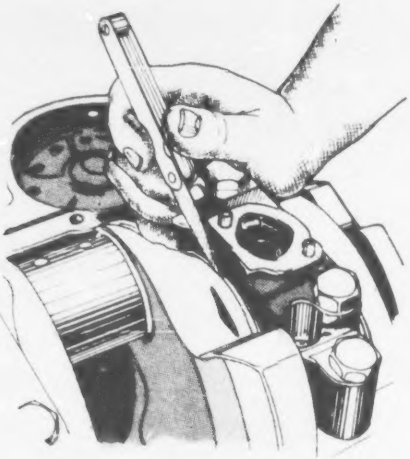
   A. Inspect the crankshaft for worn, burned, scored, pitted, rough, flaked, cracked, or otherwise damaged journals

   B. Inspect for damage to crankshaft gear and vibration damper mounting areas and keyways

   C. Inspect shaft thrust surface for wear or damage

   D. Measure clearance between thrust bearing and shaft thrust surface with a feeler gauge (Figure 1)

FIGURE 1



   E. Inspect flywheel flange for damage and check bolt holes for thread condition

   F. Inspect transmission pilot bearing area in the flywheel flange for wear or damage

JOB SHEET #2

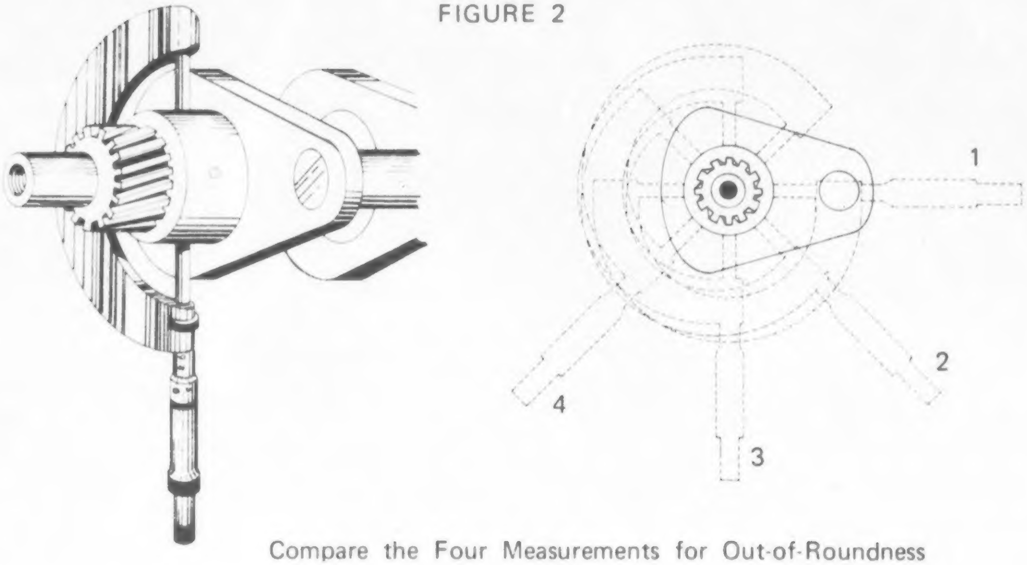
G. Measure a main bearing journal for out-of-round (Figure 2)

1. Measure main bearing journal at mid-position between oil hole and fillet; record measurement

2. Measure the journal at four positions at 45° intervals from mid-position measurement; record measurements

   (NOTE: The shaft readings should not vary more than 0.001" [0.0254 mm].)

FIGURE 2



Compare the Four Measurements for Out-of-Roundness

H. Measure a main bearing journal for taper or unevenness (Figure 3)

1. Measure main bearing journal just off the fillet; record measurement

2. Measure main bearing journal in the center, but not at the oil hole; record measurement

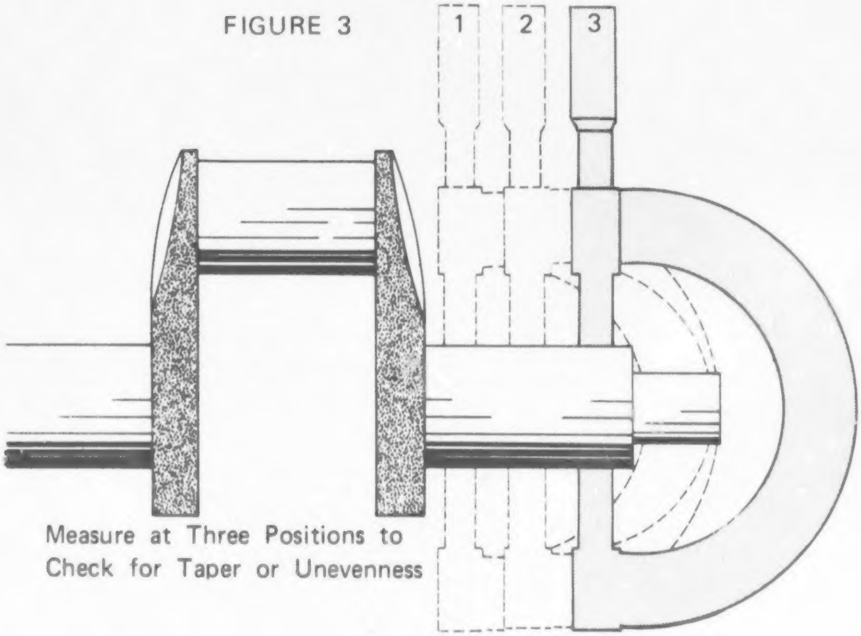
JOB SHEET #2

3. Measure main bearing journal just off the other fillet; record measurement

4. Compare the three measurements

   (NOTE: The variation should not exceed 0.0005" [0.0127 mm]. Compare these measurements to manufacturer's specifications to determine the amount of wear on the journal.)

FIGURE 3



Measure at Three Positions to Check for Taper or Unevenness

I. Measure each remaining bearing journal in the same manner as in steps A and B; record taper, out-of-round, and wear for each

J. Check crankshaft for a bent condition (Figure 4)

1. Place crankshaft on V-blocks so that the blocks contact the end main bearing journals

   (NOTE: If V-blocks are not available, the main bearing caps may be used.)

2. Place a few drops of 10 W oil on each end of main journal

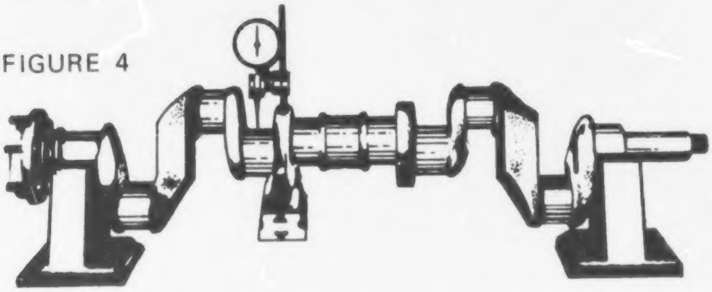
3. Position dial indicator so the contact will be against the centermost main bearing journal

JOB SHEET #2

4. Set the indicator hand to "0"

5. Rotate the crankshaft slowly while observing maximum indicator reading

FIGURE 4



(NOTE: If shaft is tapered or out-of-round more than 0.0005" [0.0127 mm] or 0.0001" [0.0254 mm] respectively, the crankshaft will require remachining or replacement. If any cracks are found, the shaft must be replaced. Other defects should be evaluated with the instructor.)

ENGINE CRANKSHAFT, BEARINGS, AND OIL PUMP
UNIT V

JOB SHEET #3--FIT A CRANKSHAFT BEARING WITH PLASTIGAUGE

I. Tools and equipment

- A. Basic hand tool set
- B. Torque wrench
- C. Plastigauge
- D. Clean shop towels

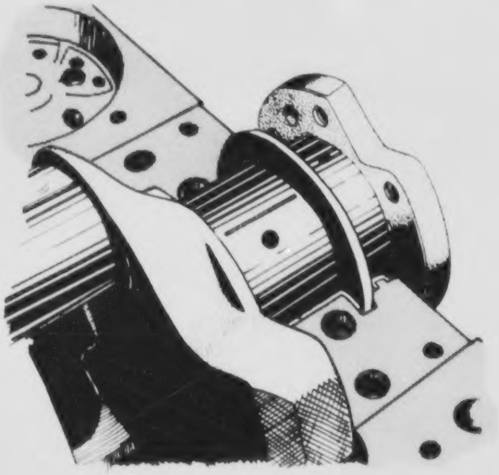
II. Procedure

A. Check main bearing clearance with engine out of vehicle

(NOTE: The engine block should be turned so that the crankcase is facing up. This will allow the weight of the crankshaft to rest on the upper bearing halves, leaving the clearance between the shaft and the bearing cap.)

1. Torque all main bearing cap bolts to specified torque
2. Remove the bearing cap from the bearing journal to be checked
3. Clean the oil off the bearing and cap
4. Clean oil off of the exposed portion of the main bearing journal (Figure 1)
5. Place a piece of plastigauge the full width of the bearing journal and parallel to the shaft (Figure 1)

FIGURE 1



JOB SHEET #3

6. Install bearing cap and evenly torque the retaining bolts to specifications

   (CAUTION: Do not rotate the crankshaft while the plastigauge is between the bearing and journal.)

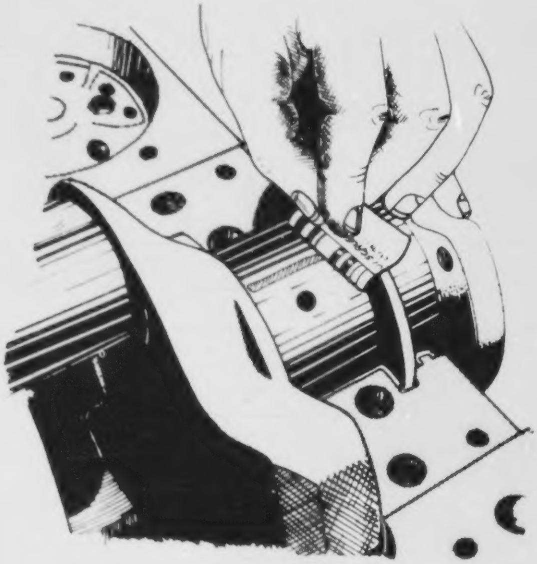
7. Remove the main bearing cap

   (NOTE: The flattened plastigauge will be found adhering to either the bearing insert or journal.)

8. Measure the compressed width at the widest point with the graduations on the plastigauge envelope (Figure 2)

   (NOTE: The graduated scale is correlated in thousandths of an inch [hundredths of a millimeter].)

FIGURE 2



(NOTE: If a bearing is being fitted to an out-of-round journal [maximum 0.001" or 0.0254 mm], be sure to fit to the maximum diameter of the journal. If flattened plastigauge tapers towards the middle or ends, the difference in clearance indicates taper, low spot, or other irregularity of the bearing or journal. Be sure to measure the journal with a micrometer if the plastigauge varies more than 0.001" [0.0254 mm].)

9. Check all rod and main bearings in this manner

JOB SHEET #3

B. Set up crankshaft to gauge bearing clearance when engine is in vehicle

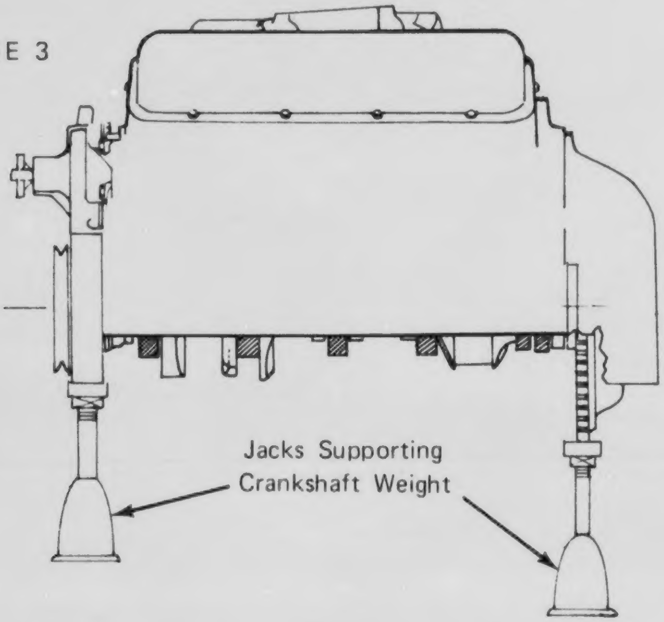
(NOTE: The procedure for measuring bearing clearance is the same whether the engine is in or out of the vehicle except for the setup procedures.)

1. Remove oil pan and oil pump

2. Support crankshaft front and rear (Figure 3)

   (NOTE: A jack on the flywheel and one on the vibration damper will allow all bearings to be checked without moving jacks.)

FIGURE 3



(CAUTION: The shaft must be held solidly in the upper bearing half in order to obtain an accurate clearance measurement.)

3. Gauge the main bearing clearance in the same manner as with the engine out of the vehicle as in step A

ENGINE CRANKSHAFT, BEARINGS, AND OIL PUMP
UNIT V

JOB SHEET #4--INSTALL A REAR MAIN BEARING SEAL (CRANKSHAFT REMOVED)

I. Tools and equipment

- A. Basic hand tool set
- B. Cylinder block
- C. Rope type seal
- D. Lip type seal
- E. Seal driver or appropriate substitute
- F. Safety glasses

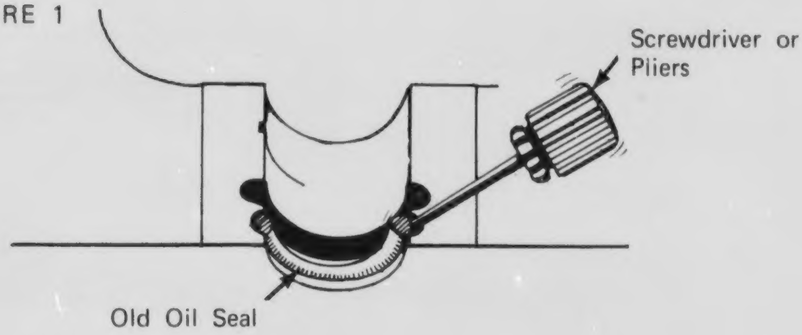
II. Procedure

(NOTE: This job sheet will describe procedures for installing the two most used types of rear main bearing seals. It is very important that the seals fit properly to avoid seal damage or oil leaks.)

A. Install a rope type rear main bearing seal

1. Remove the crankshaft if not already accomplished
2. Remove old seal from block and bearing cap by prying it out with a small screwdriver (Figure 1)

FIGURE 1

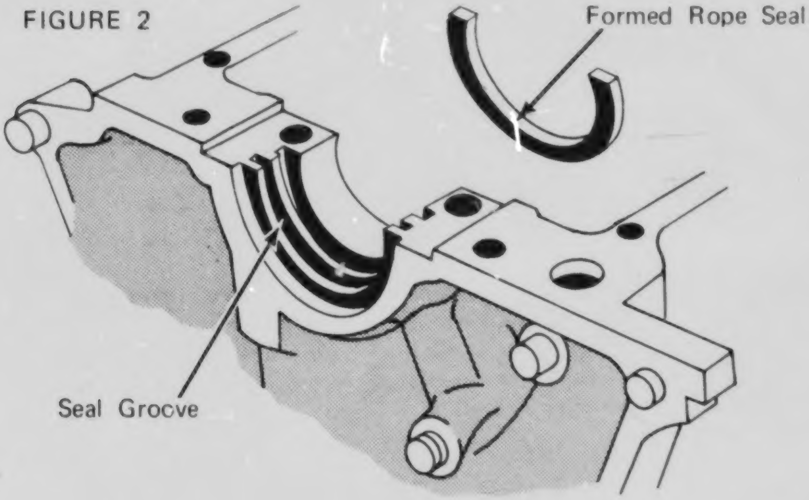


3. Clean seal groove in block and bearing cap

JOB SHEET #4

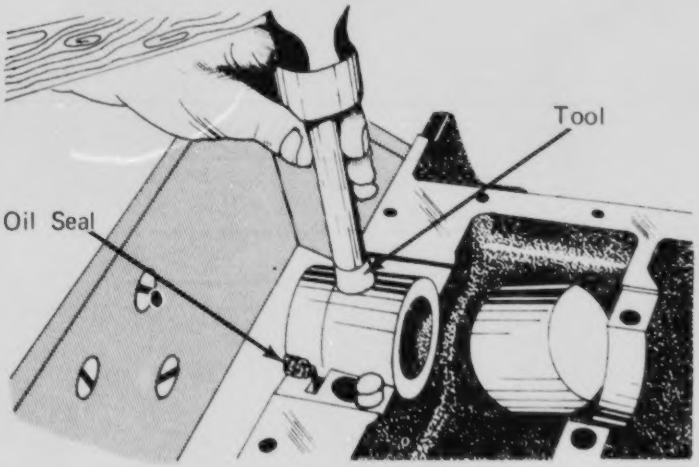
4. Form new seal half into a semicircle approximately the diameter of the seal groove (Figure 2)

FIGURE 2



5. Place seal in groove so that both ends remain above the ends of the groove (Figure 3)

FIGURE 3



6. Use driver or suitable replacement to seat the seal into the groove (Figure 3)

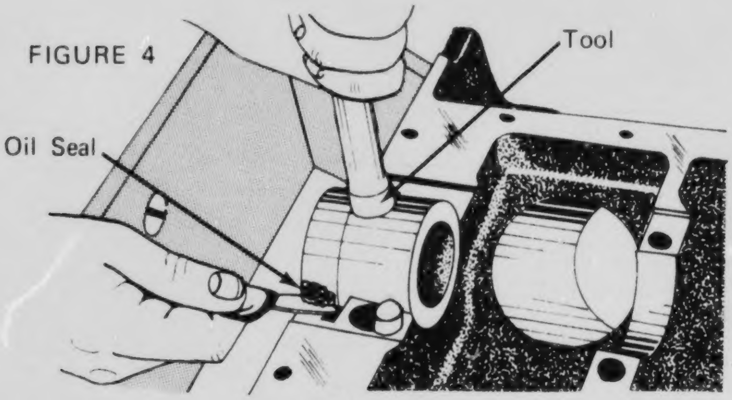
(NOTE: If driver is not available, a round object just smaller than the crankshaft journal may be used to gently tap the seal in place.)

(CAUTION: Do not overcompress seal.)

JOB SHEET #4

7. Trim ends of seal flush with block (Figure 4)

FIGURE 4



8. Install bearings in cylinder block

   (NOTE: Be sure that the oil hole in the bearing aligns with the oil hole in the block and that the bearing positioning tang is in its groove.)

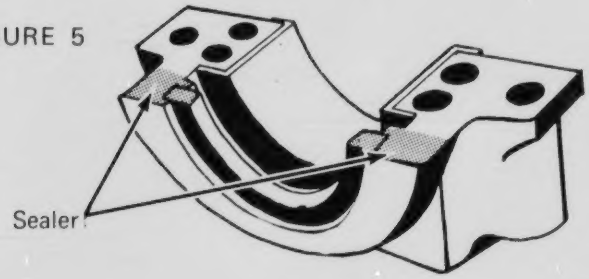
9. Apply a light film of oil on the seal edge contacting the crankshaft

10. Install crankshaft

11. Install rope seal in bearing cap in the same manner as the block half was installed in steps 1 through 8

12. Apply a light coat of nonhardening sealer to the darkened area of the main bearing cap (Figure 5)

FIGURE 5



13. Install bearing insert in the main bearing caps and lubricate

14. Install main bearing cap and torque bolts

JOB SHEET #4

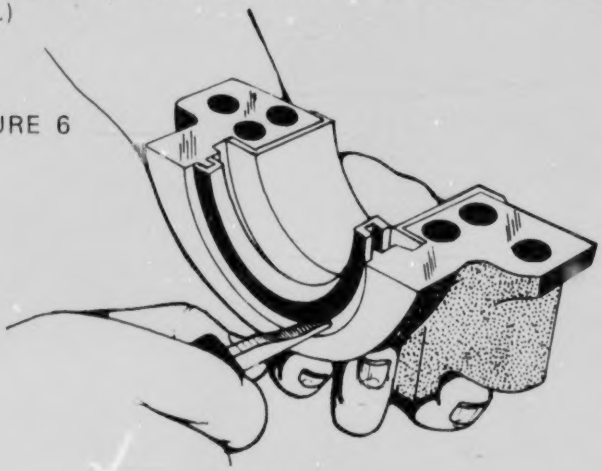
B. Install a split lip rear main bearing seal

1. Remove the crankshaft if not already accomplished

2. Remove the old seal from the block and bearing cap (Figure 6)

   (NOTE: This seal can be removed and installed with the crankshaft in place if this is the only reason for removing the shaft.)

FIGURE 6



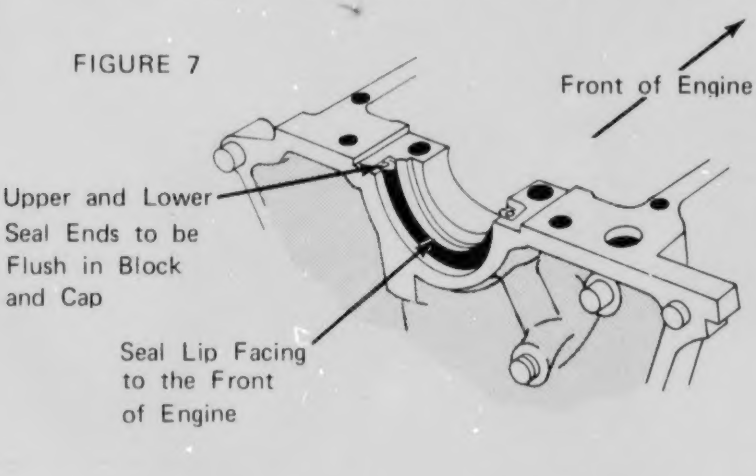
3. Clean seal groove or ridge thoroughly

4. Dip seal in oil

5. Install seal in block and main bearing cap so that the ends are flush with the edges (Figure 7)

   (NOTE: The seal lip should be facing to the front of the engine.)

FIGURE 7


Front of Engine
Upper and Lower Seal Ends to be Flush in Block and Cap
Seal Lip Facing to the Front of Engine

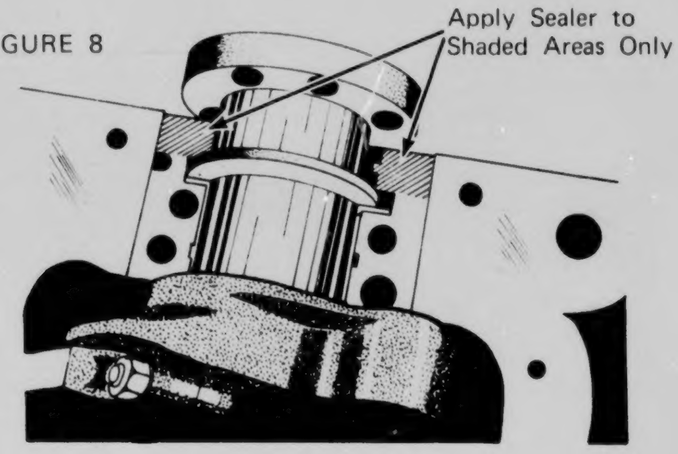
JOB SHEET #4

6. Install crankshaft

7. Apply a thin coat of sealer to main bearing cap seat in areas darkened in Figure 8

   (NOTE: No sealer should touch the seal lip.)

FIGURE 8


Apply Sealer to
Shaded Areas Only

8. Install bearing cap and torque bolts to specifications

ENGINE CRANKSHAFT, BEARINGS, AND OIL PUMP
UNIT V

JOB SHEET #5--DISASSEMBLE, CLEAN, AND INSPECT AN OIL PUMP

I. Tools

- A. Basic hand tool set
- B. Micrometer, 0 - 1" (0 - 25.4 mm)
- C. Straightedge
- D. Feeler gauge set
- E. Drill motor
- F. Drill bit, 1/8" (3.1750 mm)

II. Procedure

- A. Disassemble, clean, and inspect a rotor type pump
    1. Remove the pressure regulator valve (Figure 1)

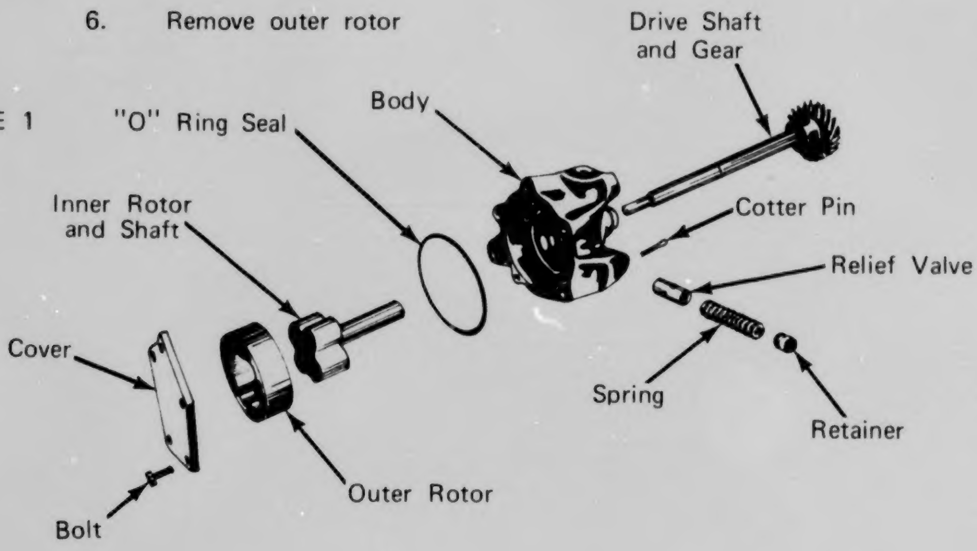
       (NOTE: Refer to Figure 1 on the following page.)

        - a. Remove cotter pin
        - b. Drill a 1/8" (3.175 mm) hole into regulator valve retainer cap
        - c. Thread a sheet metal screw into the cap
        - d. Pull the cap with the screw
    2. Remove oil pump cover bolts and lock washers
    3. Remove oil pump cover
    4. Discard oil seal ring
    5. Remove pump rotor and shaft

JOB SHEET #5

6. Remove outer rotor

FIGURE 1


Drive Shaft and Gear
Body
"O" Ring Seal
Inner Rotor and Shaft
Cotter Pin
Relief Valve
Cover
Spring
Retainer
Outer Rotor
Bolt

7. Clean all parts thoroughly in clean solvent

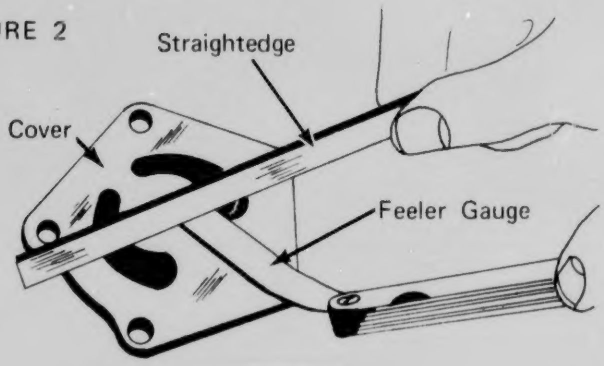
8. Inspect pump cover mating surfaces for smoothness

   (NOTE: Replace the oil pump if the cover is scratched or grooved.)

9. Lay a straightedge across the pump cover surface (Figure 2)

   (NOTE: If an 0.0015" [0.0381 mm] feeler gauge can be inserted between cover and straightedge, pump assembly should be replaced.)

FIGURE 2


Straightedge
Cover
Feeler Gauge

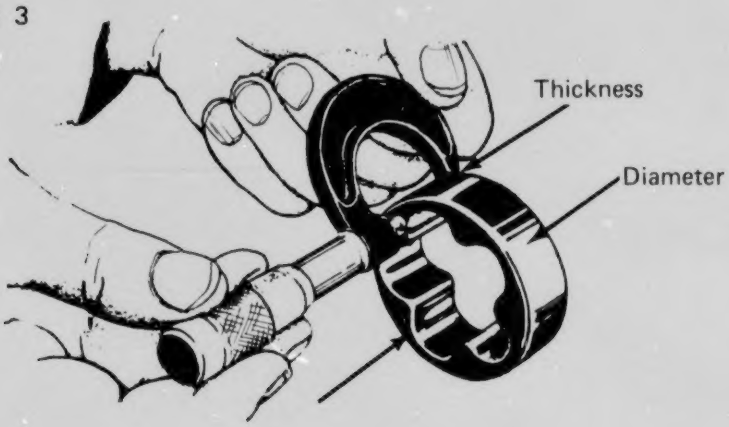
Checking Oil Pump Cover Flatness

JOB SHEET #5

10. Measure thickness of outer rotor (Figure 3)

11. Measure diameter of outer rotor (Figure 3)

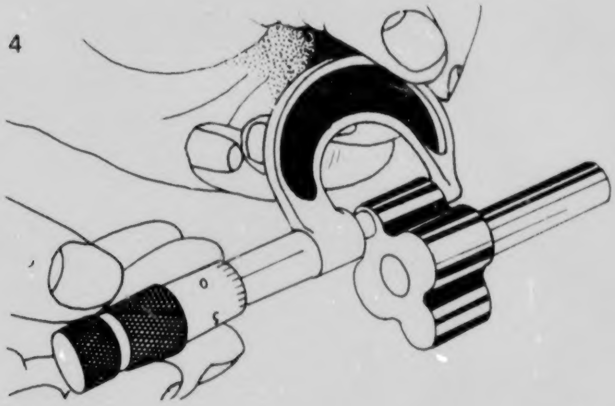
FIGURE 3



(NOTE: If rotor thickness or diameter is below specifications, replace the pump.)

12. Measure thickness of inner rotor (Figure 4)

FIGURE 4



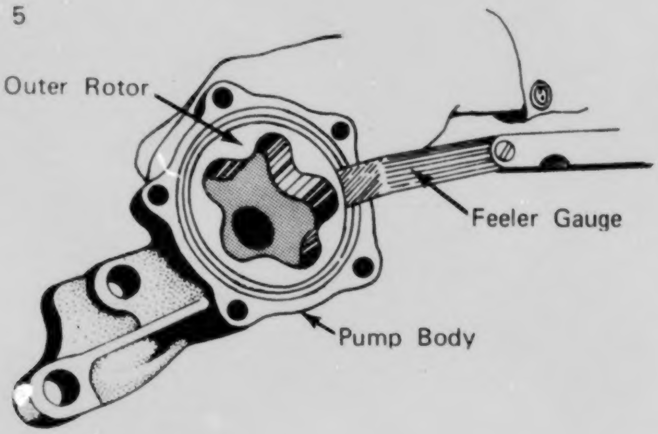
13. Inspect pump body visually for wear and scoring

14. Place outer rotor into pump body

JOB SHEET #5

15. Press rotor to one side with fingers and measure clearance between rotor and pump body (Figure 5)

FIGURE 5

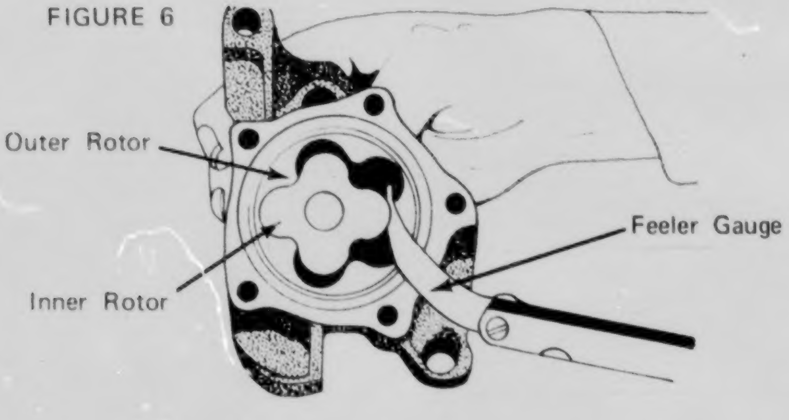

Outer Rotor
Feeler Gauge
Pump Body

(NOTE: If measurement exceeds specifications, replace the pump.)

16. Install inner rotor into pump body

17. Measure clearance between inner and outer rotor (Figure 6)

FIGURE 6

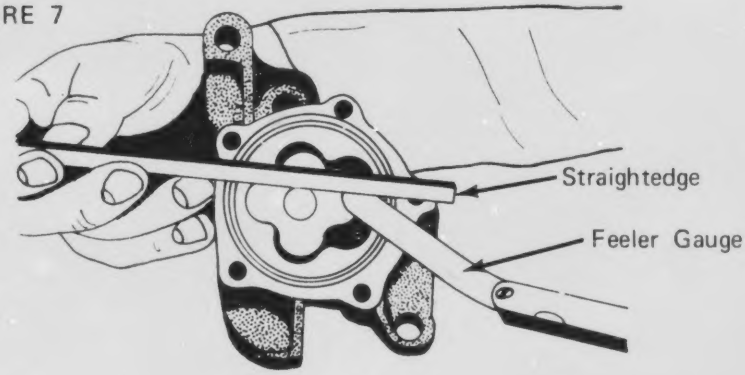

Outer Rotor
Feeler Gauge
Inner Rotor

(NOTE: Replace the pump if clearance exceeds specifications.)

JOB SHEET #5

18. Place the straightedge across the face of the pump body between bolt holes (Figure 7)

FIGURE 7



(NOTE: If an 0.004" [0.1016 mm] or more feeler gauge can be inserted between straightedge and rotors, replace the pump assembly.)

19. Inspect the pressure regulator valve plunger for scoring and free operation in the bore

(NOTE: Small marks may be removed with #400 grit wet or dry sandpaper.)

20. Measure free length of pressure regulator valve spring and compare with specifications

(NOTE: Reassemble the pump if measurements are within specifications.)

21. Install a new oil seal in pump body groove

22. Set pump cover in place and secure with screws and lock washers

23. Torque screws to proper specifications

(NOTE: Prime the pump before installation by pouring oil in the inlet passage while rotating rotor shaft.)

JOB SHEET #5

B. Disassemble, clean, and inspect a gear type pump

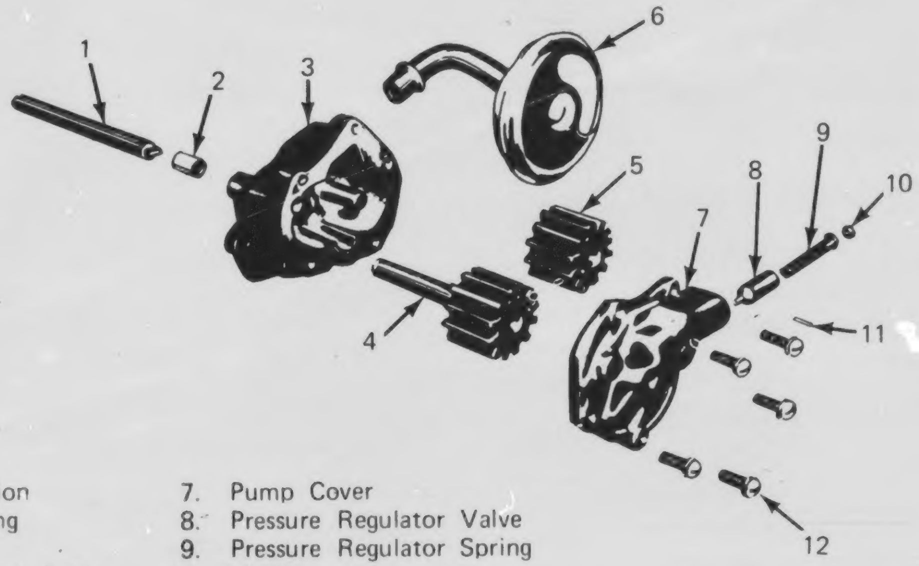
1. Remove the pump cover attaching screws
2. Remove the pump cover (Figure 8)

   (NOTE: The pump cover may have a gasket, O-ring seal, or a metal-to-metal seal depending on the manufacturer.)

3. Mark gear teeth so they may be reassembled with the same teeth indexing
4. Remove the drive gear and shaft from pump body
5. Remove the idler gear from pump body
6. Remove the pressure regulator valve retaining pin, pressure regulator valve, and related parts
7. Remove pump pickup screen
   a. Place pump body in a soft-jawed vise
   b. Pull or tap pickup screen and pipe out of pump body

   (CAUTION: Do not disturb the pickup screen on the pipe. This is serviced as an assembly only.)

FIGURE 8



1. Shaft Extension
2. Shaft Coupling
3. Pump Body
4. Drive Gear and Shaft
5. Idler Gear
6. Pickup Screen and Pipe
7. Pump Cover
8. Pressure Regulator Valve
9. Pressure Regulator Spring
10. Washer
11. Retaining Pin
12. Screws

JOB SHEET #5

8. Clean and inspect oil pump
    a. Wash all parts in cleaning solvent and dry with compressed air
    b. Inspect the pump body and cover for cracks or excessive wear
    c. Inspect pump gears for damage or excessive wear
    d. Check the drive gear shaft for looseness in the pump body
    e. Inspect the pickup screen and pipe assembly for damage
    f. Check the pressure regulator valve for fit

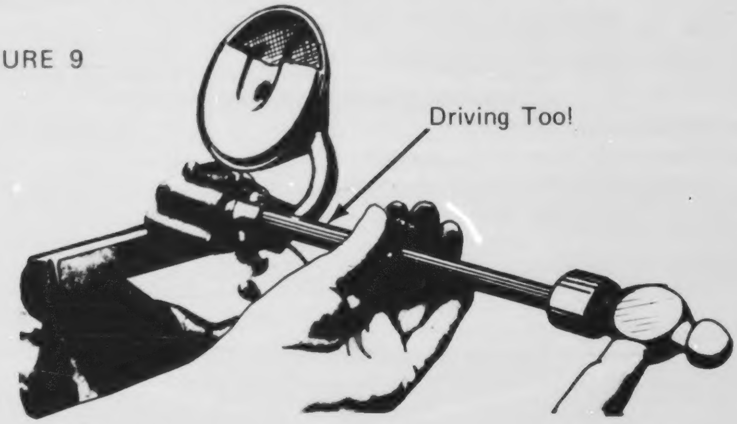
    (NOTE: If the pump gears or body are damaged or worn, replacement of the entire assembly is necessary.)

9. Assemble the gear type pump
    a. Install pressure regulator valve and related parts
    b. Install drive gear and shaft into pump body
    c. Install the idler gear into the pump body in the same direction as removed while aligning the indexing marks
    d. Install pump cover using the appropriate gasket or seal as necessary
    e. Torque cover attaching screws to specifications
    f. Turn drive shaft by hand to check for smooth operation

JOB SHEET #5

g. Install pickup screen and pipe assembly (Figure 9)

FIGURE 9



(NOTE: Replace the pickup screen and pipe assembly with a new one when it is removed because the press fit may leak when installed the second time and will cause low oil pressure.)

ENGINE CRANKSHAFT, BEARINGS, AND OIL PUMP
UNIT V

TEST

NAME ________________________________ SCORE ____________________

1. Match the terms on the right to the correct definitions.

_____a. Process of hammering or compressing a red hot metal part to form it into the desired shape

_____b. That portion of the crankshaft upon which the connecting rod fastens

_____c. Diameter of a hole

_____d. Part made by pouring melted metal into a mold where it cools to the shape of the mold

_____e. Notch or lip on a bearing shell used to correctly locate the bearing during assembly and operation

_____f. Small-sized plastic thread for measuring clearances by the amount it is smashed between the parts

_____g. Round, weighted device attached to the front of the crankshaft to minimize the torsional (twisting) vibration of the shaft

_____h. Bearing in the back of the crankshaft that supports the front of the clutch shaft

_____i. Surface that supports a moving load with minimum drag

_____j. Spacing device; usually a sleeve with a bearing surface on the inside

_____k. Slight distortion of the bearing shell that holds it in place as the engine operates

1. Torsional vibration damper
2. Idler gear
3. Forging
4. Bore
5. Bearing
6. Cast
7. Plastigauge
8. Pilot bearing
9. Journal
10. Bearing crush
11. Crankpin
12. Bushing
13. Bearing tang
14. Bearing spread

_____l. Surface on which a bearing operates

_____m. Rotating gear that does not transfer a load

_____n. Split-sleeve bearings have a slightly larger arc than the bearing housing bore

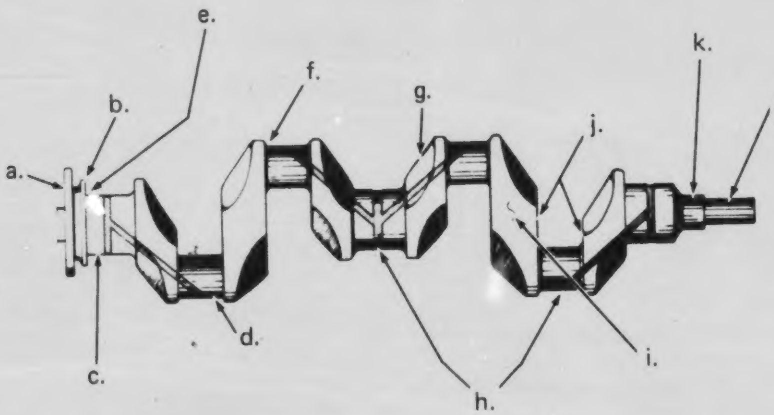
2. Write the purpose of the crankshaft.

____

____

____

3. Identify the parts of the crankshaft below by writing the correct names in the blanks provided.



a. ____________________ g. ____________________

b. ____________________ h. ____________________

c. ____________________ i. ____________________

d. ____________________ j. ____________________

e. ____________________ k. ____________________

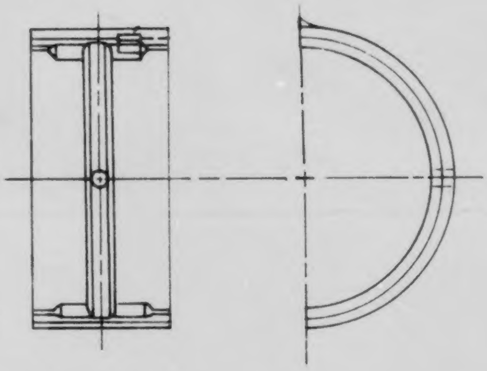
f. ____________________ l. ____________________

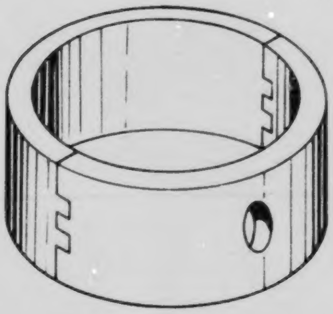
4. List two methods used to manufacture crankshafts.

a. ____

b. ____

5. Identify the following types of bearings used on the cam and crankshaft.





a. ______________________ b. ______________________

6. List the layers of materials used to make insert bearings.

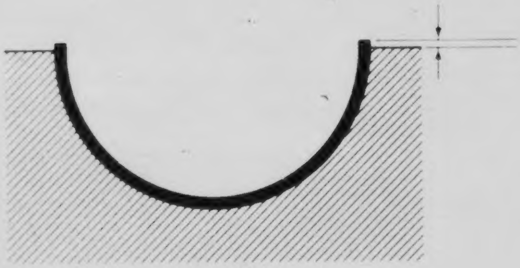
a. ______________________

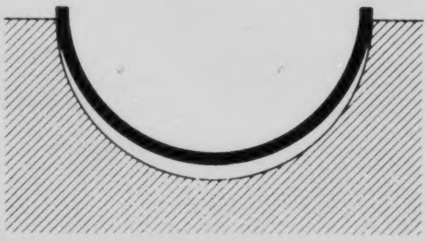
b. ______________________

c. ______________________

d. ______________________

7. Distinguish between bearing spread and bearing crush by placing the name in the blank below the correct drawing.





a. ______________________ b. ______________________

8. Match the bearing requirements on the right to the correct definitions.

_____a. Ability to permit foreign particles to become compressed into the soft bearing surface to protect the smooth crankshaft

_____b. Ability of the soft bearing surface to change to variations in shaft alignment and journal shape

_____c. Ability to support the severe centrifugal and combustion forces in the engine

_____d. Hard and tough enough to maintain a long service life

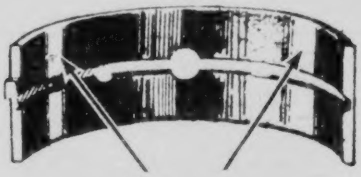
_____e. Ability to resist the corrosive effect of combustion by-products

_____f. Resistance to severe pressures and bending without failure

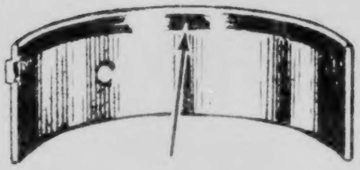
1. Load-carrying capacity
2. Embeddability
3. Fatigue resistance
4. Conformability
5. Corrosion resistance
6. Wear rate

9. Match the causes of bearing failure on the right to the correct illustration. (Illustrations are continued on the next page.)

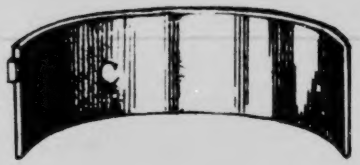
1. Fatigue failure
2. Improper seating
3. Lack of oil
4. Scratched by dirt
5. Tapered journal
6. Radius ride



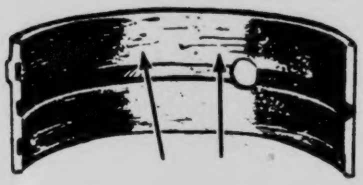
_____a.



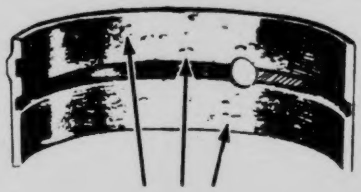
_____b.



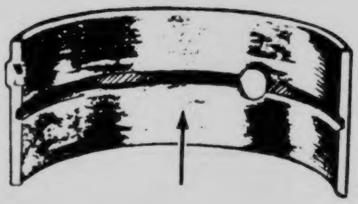
______c.



______d.



______e.



______f.

10. Discuss the action of lubrication oil in an insert type bearing.

____

____

____

____

____

11. Distinguish between a torsional vibration damper and a flywheel by placing an "F" in front of the purpose of a flywheel.

_____ a. Opposes crankshaft torsional vibration or the twist-untwist action of the crankshaft caused by the cylinder firing impulse

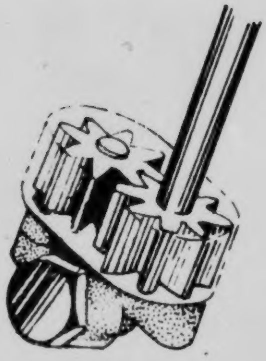
_____ b. Evens out the power surges from power stroke to power stroke

12. List two types of rear main bearing oil seals.

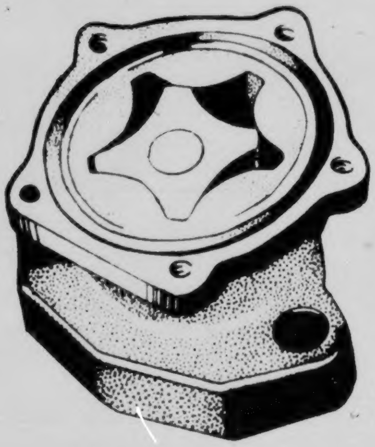
a. ____

b. ____

13. Identify the following oil pumps.

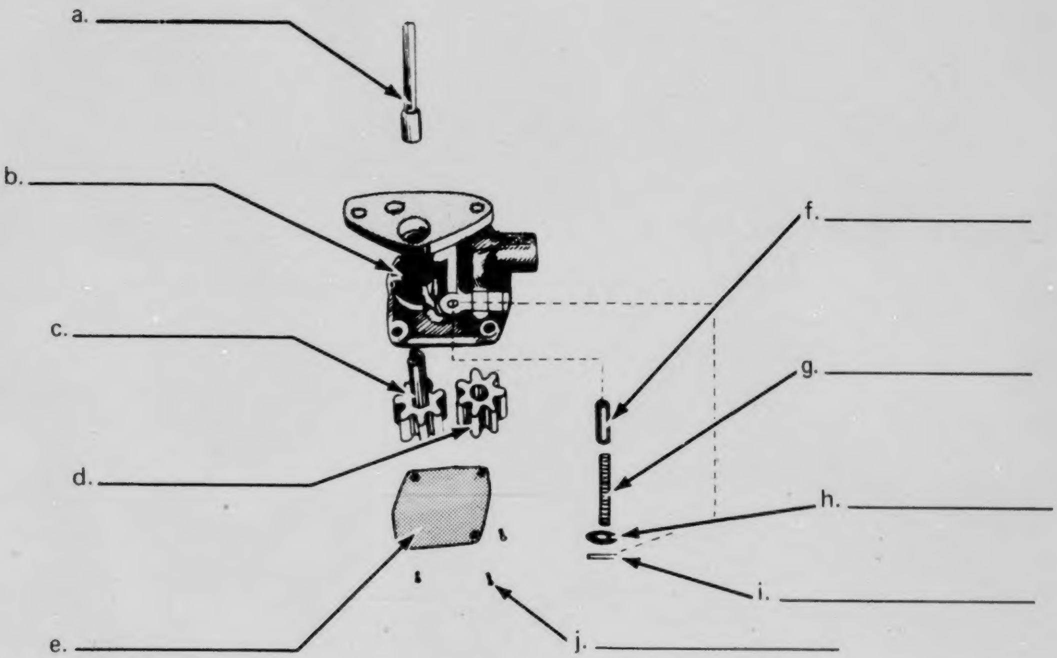


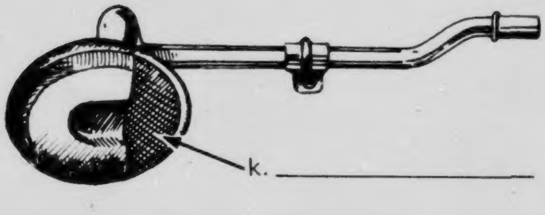
a. ________________________



b. ________________________

14. Identify the parts of the oil pump below by writing the correct names in the blanks provided.


a.
b.
f.
c.
g.
d.
h.
i.
e.
j.



15. Select from the list below the conditions that could cause low oil pressure.

_____a. Air leak in pickup screen and pipe

_____b. Excessive camshaft bearing clearance

_____c. Worn oil pump

_____d. Low oil level

_____e. Improper lubricating oil viscosity

_____f. Improperly adjusted valves

_____g. Excessive main bearing clearance

_____h. Excessive rod bearing clearance

_____i. Low engine compression

_____j. Leaks in oil passageways in cylinder block

_____k. Broken oil pressure regulator spring

16. Demonstrate the ability to:

a. Check main bearing bore alignment.

b. Measure and inspect a crankshaft.

c. Fit a crankshaft bearing with plastigauge.

d. Install a rear main bearing seal (crankshaft removed).

e. Disassemble, clean, and inspect an oil pump.

(NOTE: If these activities have not been accomplished prior to the test, ask the instructor when they should be completed.)

ENGINE CRANKSHAFT, BEARINGS, AND OIL PUMP
UNIT V

ANSWERS TO TEST

1. a. 3
   b. 11
   c. 4
   d. 6
   e. 13
   f. 7
   g. 1
   h. 8
   i. 5
   j. 12
   k. 10
   l. 9
   m. 2
   n. 14

2. To change the reciprocating motion of the pistons to a rotating motion

3. a. Flywheel flange
   b. Oil slinger
   c. Main bearing journal
   d. Crankpin (connecting rod journal)
   e. Thrust bearing area
   f. Crankpin fillet
   g. Crank web
   h. Oil passages
   i. Counterweight
   j. Crank cheek
   k. Crankshaft gear (cam drive gear mounting area)
   l. Pulley and damper mounting area

4. a. Cast
   b. Forge

5. a. Split sleeve
   b. Sleeve

6. a. Steel back
   b. Inner layer of bearing alloy
   c. Thin overlay of a soft bearing alloy
   d. Barrier plating

7. a. Crush
   b. Spread

8. a. 2
   b. 4
   c. 1
   d. 6
   e. 5
   f. 3

9. a. 2
   b. 6
   c. 5
   d. 4
   e. 1
   f. 3

10. Discussion should include that the lubrication oil keeps the bearing and rotating shaft journal separated by a film of oil so there is no actual metal-to-metal contact

11. b

12. a. Lip
    b. Rope

13. a. Gear
    b. Rotor

14. a. Extension shaft
    b. Pump body
    c. Drive gear and shaft
    d. Idler gear
    e. Pump cover
    f. Pressure regulator valve
    g. Pressure regulator spring
    h. Washer
    i. Retaining pin
    j. Screws
    k. Pickup screen and pipe

15. a, b, c, d, e, g, h, j, k

16. Performance skills evaluated to the satisfaction of the instructor

CYLINDER AND PISTON RECONDITIONING
UNIT VI

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify parts of the cylinder piston, types of cylinder wear, piston damage, and tools and equipment used in piston and cylinder repair. The student should be able to clean, inspect, measure, repair, and assemble a piston and cylinder assembly. This knowledge will be evidenced through demonstration and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with cylinder and piston reconditioning to the correct definitions.
2. Identify cylinder wear patterns.
3. List methods of reconditioning cylinders.
4. Name types of cylinder sleeves.
5. Discuss the reason that cylinders taper as they wear.
6. Identify parts of the cylinder block.
7. Name types of cylinder block core hole plugs.
8. Identify parts of a piston and connecting rod assembly.
9. Identify types of compression rings.
10. Match compression rings to the correct methods of installation.
11. Identify types of oil rings.
12. List methods for installing oil rings.
13. Match methods of heat and expansion control in a piston to the correct descriptions.
14. Match piston conditions to the correct causes.
15. List methods of lubricating cylinder walls and piston pins.
16. Identify tools and equipment used in reconditioning cylinders and pistons.
17. Identify types of piston pin locks.

18. Demonstrate the ability to:
    - a. Remove piston ring ridge from cylinder.
    - b. Measure a cylinder for taper, wear, and out-of-round.
    - c. Hone a cylinder with a glaze breaker hone.
    - d. Clean the cylinder head surface and check for warpage.
    - e. Remove and replace a cylinder block core plug.

CYLINDER AND PISTON RECONDITIONING
UNIT VI

SUGGESTED ACTIVITIES

I. Suggested activities for the instructor.

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Secure materials and equipment for job sheet demonstrations.

   E. Discuss unit and specific objectives.

   F. Discuss information sheet.

   G. Demonstrate and discuss procedures outlined on the job sheets.

   H. Give test.

   I. Evaluate student performance of job sheets.

II. Unit references:

   A. Ellinger, Herbert E. *Automechanics.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc. 1972.

   B. Crouse, William G. *Automotive Engine Design*. New York: McGraw-Hill Book Co., 1975.

   C. Crouse, William G. *Automotive Mechanics.* 7th ed. New York: McGraw-Hill Book Co., 1975.

   D. *Chevrolet Service Manual*. Detroit: Chevrolet Motor Div./General Motors Corp., 1977.

   E. *Chrysler, Plymouth, Dodge Chassis Service Manual.* Detroit: Chrysler Corp., 1976.

   F. *Ford Service Manual*. Dearborn, Michigan: Ford Motor Co., 1975-76.

CYLINDER AND PISTON RECONDITIONING
UNIT VI

INFORMATION SHEET

I. Terms and definitions

   A. Blow-by--Combustion gases that slip past the piston and rings to get into the crankcase

   B. Knurl--To roughen the surface of a piece of metal by pressing a series of cross-hatched lines into the surface and thereby raising the area between these lines

      (NOTE: It is a process used to enlarge worn piston skirts.)

   C. Lands--Large diameter portion between piston ring grooves

   D. Lifter valley--Chamber between the cylinder bores on a V-block engine

   E. Piston slap--Sound made by a piston with excess skirt clearance as the crankshaft goes across top center

   F. Pop-up--Raised portion of a piston head

   G. Ream--To size a hole to exact dimensions with a cutting tool called a *reamer*

      (NOTE: Reaming is used to fit piston pins and other such bearings.)

   H. Bore--Diameter of an engine cylinder

   I. Cylinder block--Basic framework of the engine to which the other engine parts are attached

   J. Cylinder hone--Expandable rotating tool with abrasive fingers turned by a electric motor; used to clean and smooth the inside surface of a cylinder

   K. Oil control ring--Lower ring or rings on a piston; designed to prevent excessive amounts of oil from working up into the combustion chamber

   L. Ring expander tool--Special tool used to expand piston rings for installation on the piston

   M. Ring ridge--That portion of the cylinder above the top limit of ring travel

      (NOTE: In a worn cylinder, this area is of a smaller diameter than the remainder of the cylinder.)

INFORMATION SHEET

II. Cylinder wear patterns (Transparency 1)

  A. Taper

  B. Out-of-round

  C. Wear

III. Methods of reconditioning cylinders (Transparency 2)

  A. Hone

  B. Bore

  C. Sleeve

IV. Types of cylinder sleeves (Transparency 3)

  A. Dry

  (NOTE: A dry sleeve is fitted inside the cylinder bore with a press fit. Engine coolant does not contact the sleeve.)

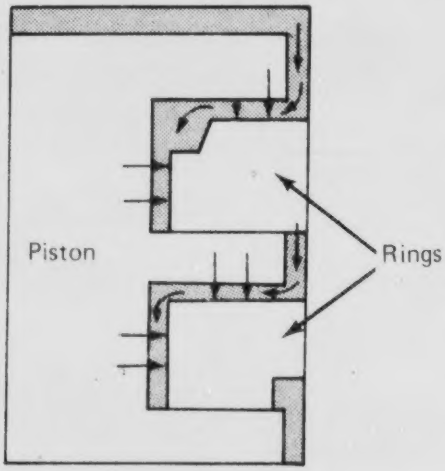
  B. Wet

  (NOTE: The wet sleeve is fitted into a specially prepared block. The sleeve forms the cylinder in the block and is sealed at top and bottom to prevent coolant from leaking.)

V. Reason cylinders wear tapered

  A. Cylinder pressure is created during compression and power stroke in the ring grooves and behind the ring, forcing the ring against the bottom of the groove and out against the cylinder wall

  B. Since the greater pressure is created when the piston is at the top of the cylinder, the rings create more wear at the top of the cylinder



INFORMATION SHEET

C. Less lubricating oil reaches the upper cylinder area, increasing friction

D. More heat is concentrated in the upper cylinder area due to the burning fuel

VI. Parts of the cylinder block (Transparency 4)

A. Cylinder

B. Head mating surface

C. Camshaft bore

D. Main bearing support

E. Core hole

F. Water jacket

G. Valve lifter chamber

VII. Types of cylinder block core hole plugs (Transparency 5)

A. Cup

B. Expansion cup

C. Expansion disc

VIII. Parts of a piston and connecting rod assembly (Transparency 6)

A. Parts of a piston

1. Head
2. Pin boss
3. Pin bearing
4. Skirt section
5. Ring section
6. Ring groove
7. Ring land
8. Piston pin
9. Heat dam

INFORMATION SHEET

B. Parts of a connecting rod assembly

  1. Rod
  2. Rod cap
  3. Bolt
  4. Nut
  5. Bearing insert
  6. Spit hole
  7. Bearing lock groove

IX. Types of compression rings (Transparency 7)

  A. Tapered
  B. Chamfered
  C. Counterbored
  D. Scraper
  E. Plain
  F. Center grooved

X. Methods of installing compression rings (Transparency 8)

  A. Inside groove up
  B. Word *TOP* up
  C. Scraper edge down
  D. Outside groove down
  E. Dash or dot up
  F. Either side up

XI. Types of oil rings (Transparency 7)

  A. Radius slotted
  B. Wedge slotted
  C. Drilled

INFORMATION SHEET

D. Slotted

E. Three-piece

(NOTE: The three-pieced oil ring is the most common ring used.)

XII. Methods of installing oil rings (Transparency 8)

A. One piece--Either side up

B. Two piece--Expander gap 180° from ring gap

C. Three piece--Expander with ends butted together and steel rail gaps 180° apart and 90° from expander gap

XIII. Methods of heat and expansion control in the piston (Transparency 9)

A. Heat dam--Groove around the top of the piston that reduces the flow of heat from the piston head to the piston skirt

B. Horizontal or vertical slot in piston skirt--T-shaped slot that breaks the path of heat traveling to the skirt and allows for skirt expansion without increasing diameter

C. Cam ground piston--Piston skirt is ground to a cam shape and contacts only in the center when it is cold; as it heats up it becomes round to fit the cylinder more completely

D. Steel band or belt--Steel band cast into the piston pin boss that reduces expansion of the piston skirt due to heat and conducts heat out through pin boss

(NOTE: One of these methods of heat and expansion control is used in the pistons of most automobile engines.)

XIV. Piston conditions and related causes (Transparencies 10, 11, and 12)

A. Cracked piston skirt--Piston improperly fitted to cylinder

B. Moderate and severe skirt damage--Cylinder detonation

C. Piston head damage--Pre-ignition or overheated cylinder

D. Piston skirt wear--Misaligned connecting rod

E. Piston pin boss and ring land damage--Loose or broken piston pin lock ring

F. Piston rings stuck in groove--Excessive carbon deposit buildup

G. Ring land damage--Broken piston ring and pre-ignition

H. Excessively worn upper ring groove--Poor maintenance, poor air filtration, or service abuse

INFORMATION SHEET

XV. Lubrication of cylinder walls and piston pins (Transparency 13)

A. Splash system

B. Spit oil hole in rod

C. V-groove in rod

XVI. Tools and equipment used in reconditioning cylinders and pistons (Transparency 14)

A. Cylinder gauge

B. Ring expander

C. Ring compressor

D. Boring hone

E. Glaze breaker hone

F. Piston pin press

G. Sleeve puller and press

H. Boring bar

I. Piston gauge and scale

J. Ring groove gauge

XVII. Types of piston pin locks (Transparency 15)

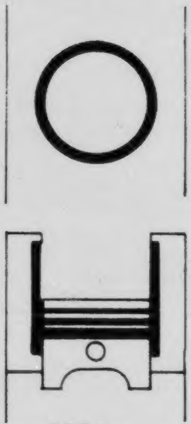
A. Locked to connecting rod

B. Free floating

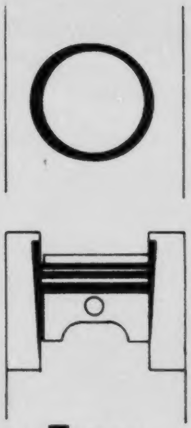
C. Locked to piston

D. Pressed-in rod

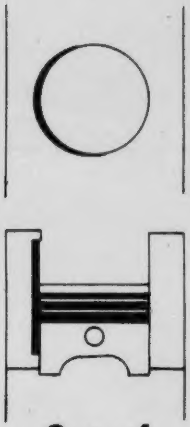
Cylinder Wear Patterns



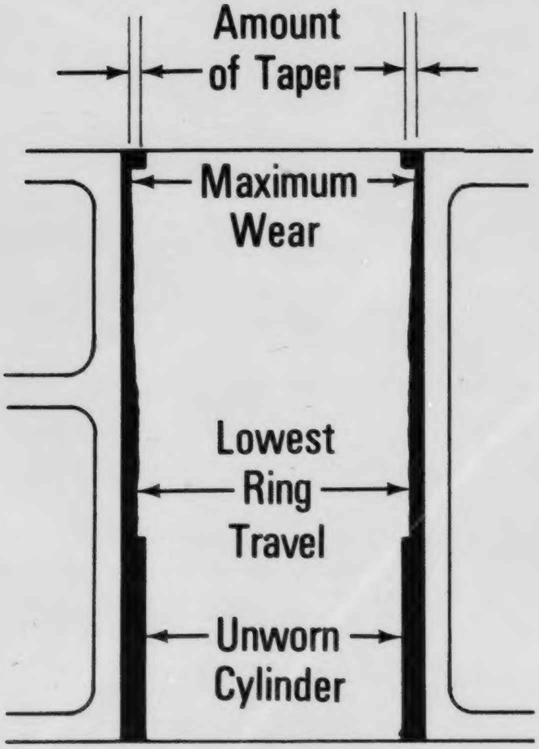
Wear



Taper

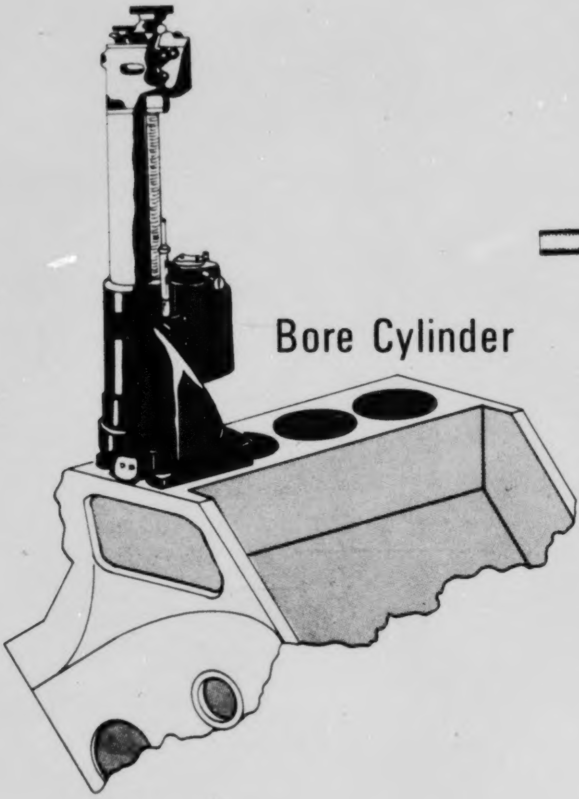


Out of Round

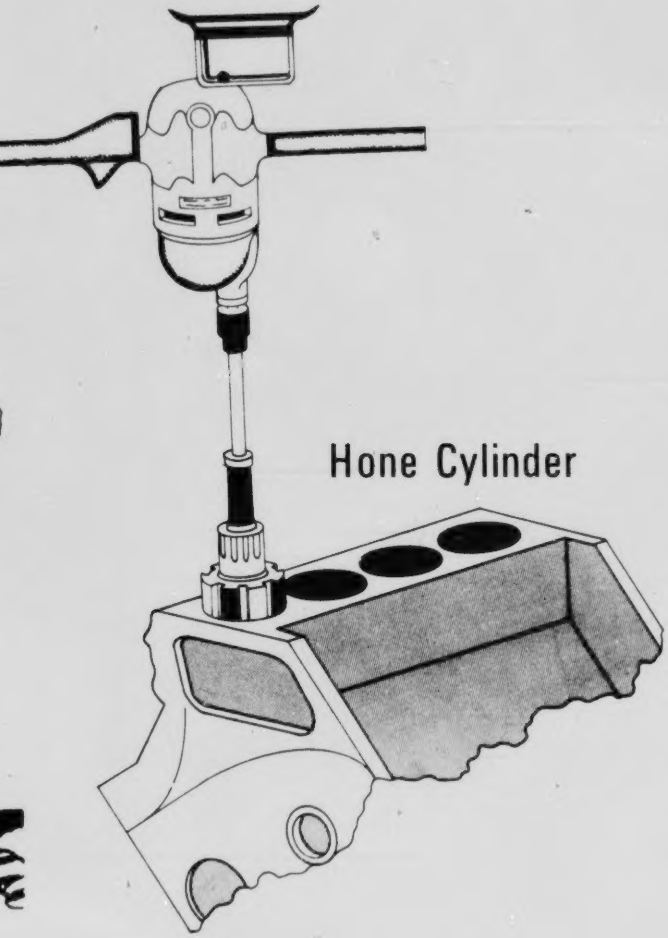


Amount of Taper
Maximum Wear
Lowest Ring Travel
Unworn Cylinder

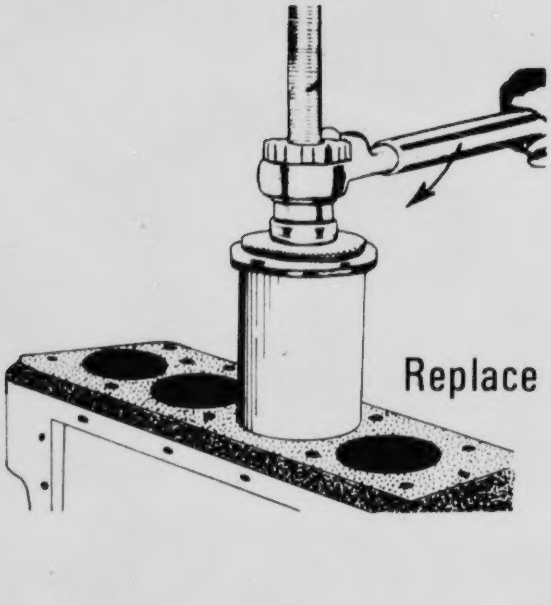
Methods of Reconditioning Cylinders



Bore Cylinder



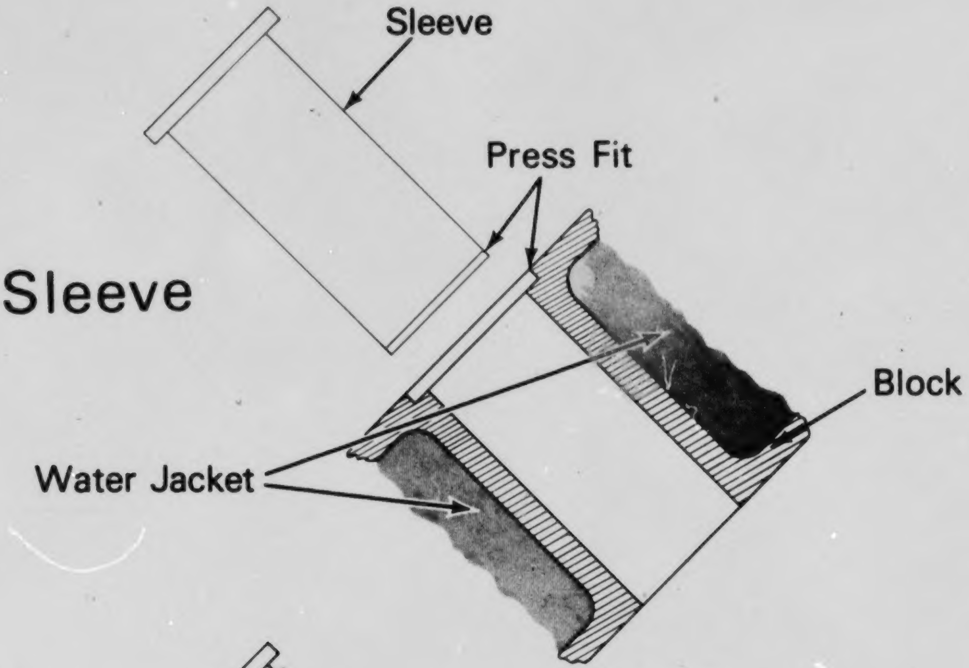
Hone Cylinder



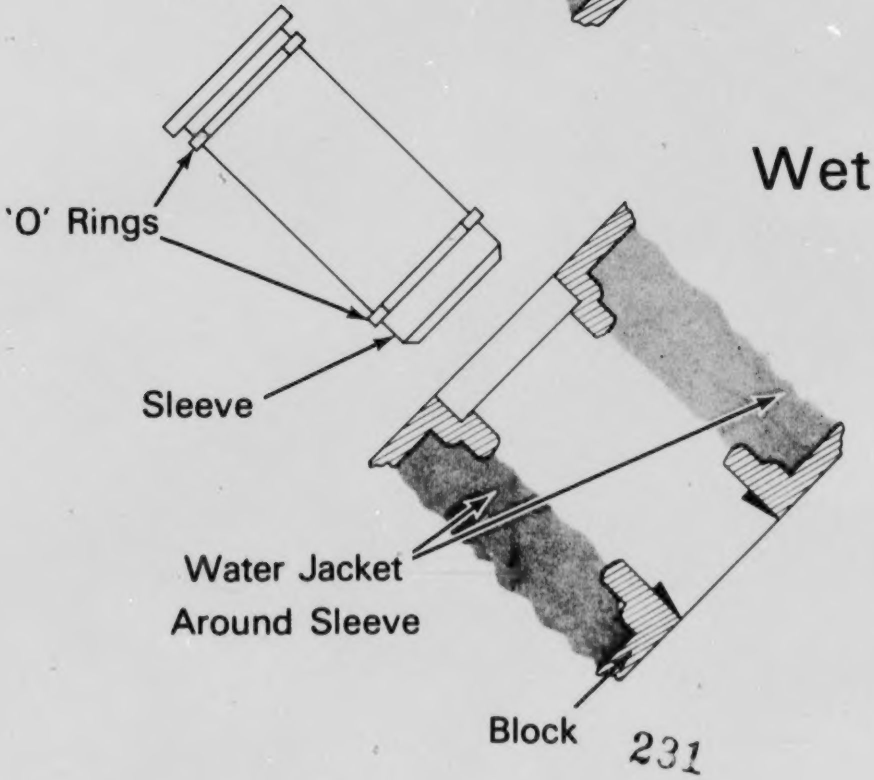
Replace Sleeve

Types of Cylinder Sleeves

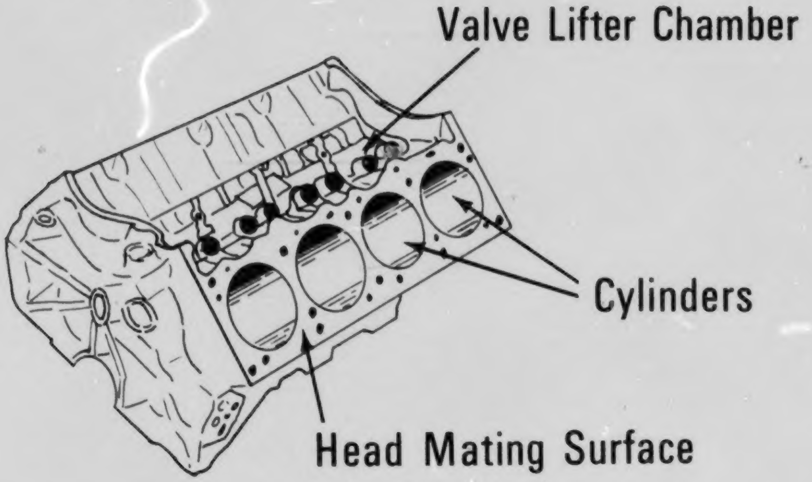
Dry Sleeve

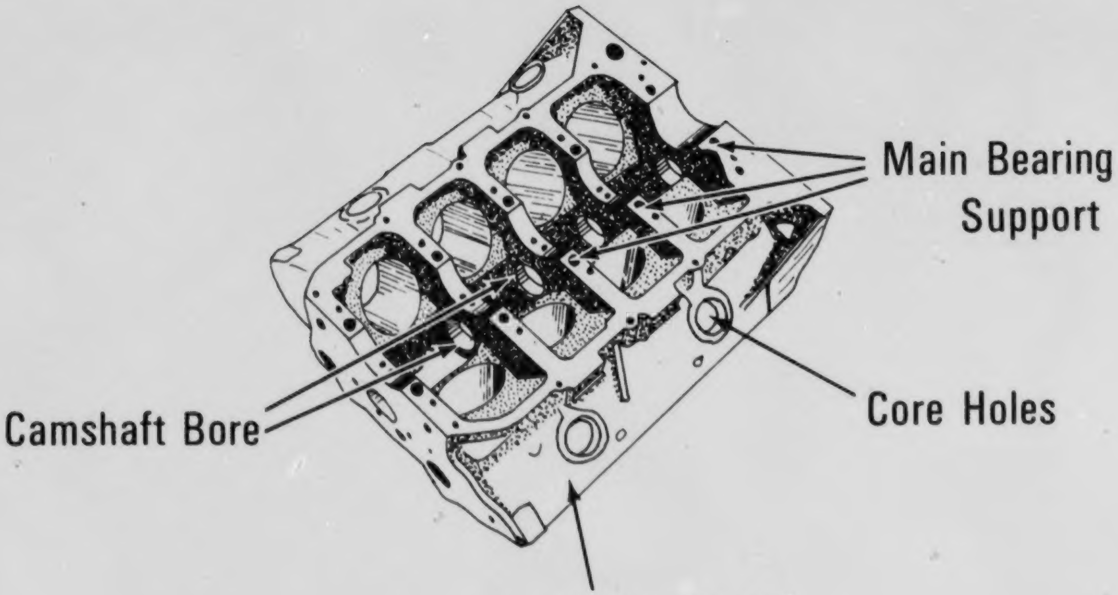

Sleeve
Press Fit
Block
Water Jacket

Wet Sleeve

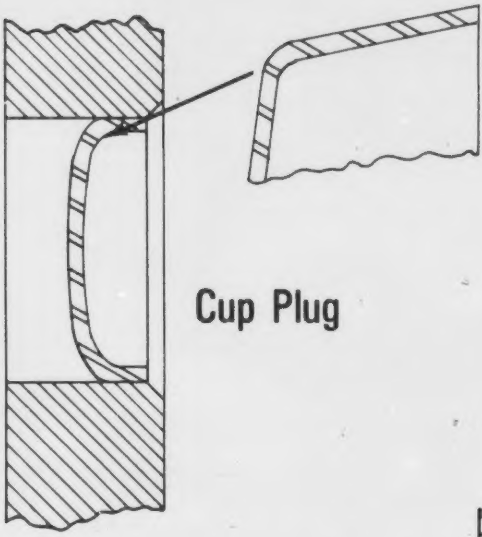

'O' Rings
Sleeve
Water Jacket
Around Sleeve
Block

Parts of the Cylinder Block

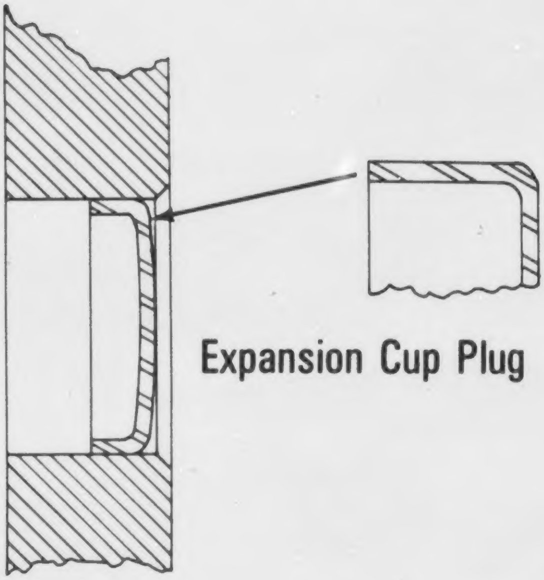

Valve Lifter Chamber
Cylinders
Head Mating Surface


Main Bearing Support
Core Holes
Camshaft Bore
Water Jacket

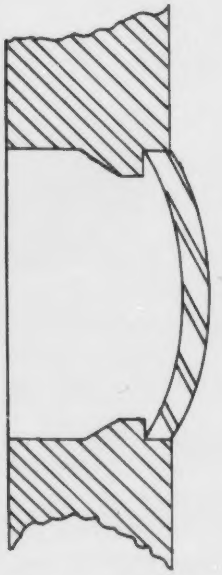
Types of Cylinder Block Core Plugs



Cup Plug



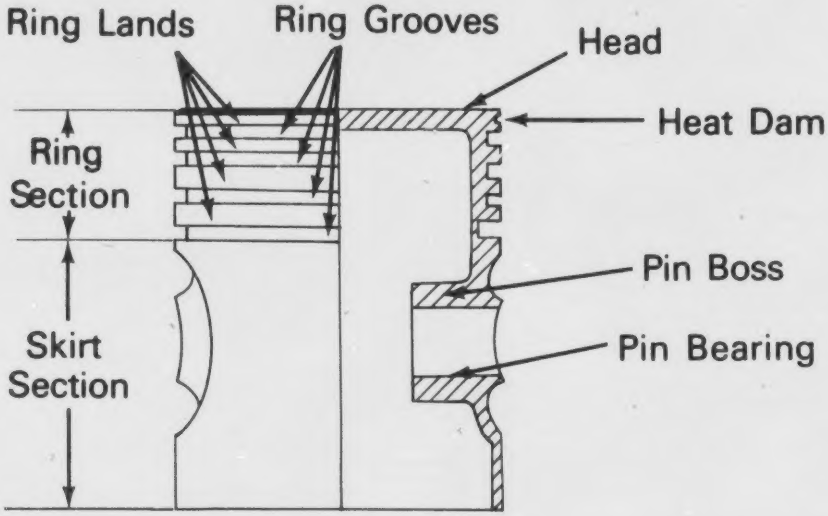
Expansion Cup Plug



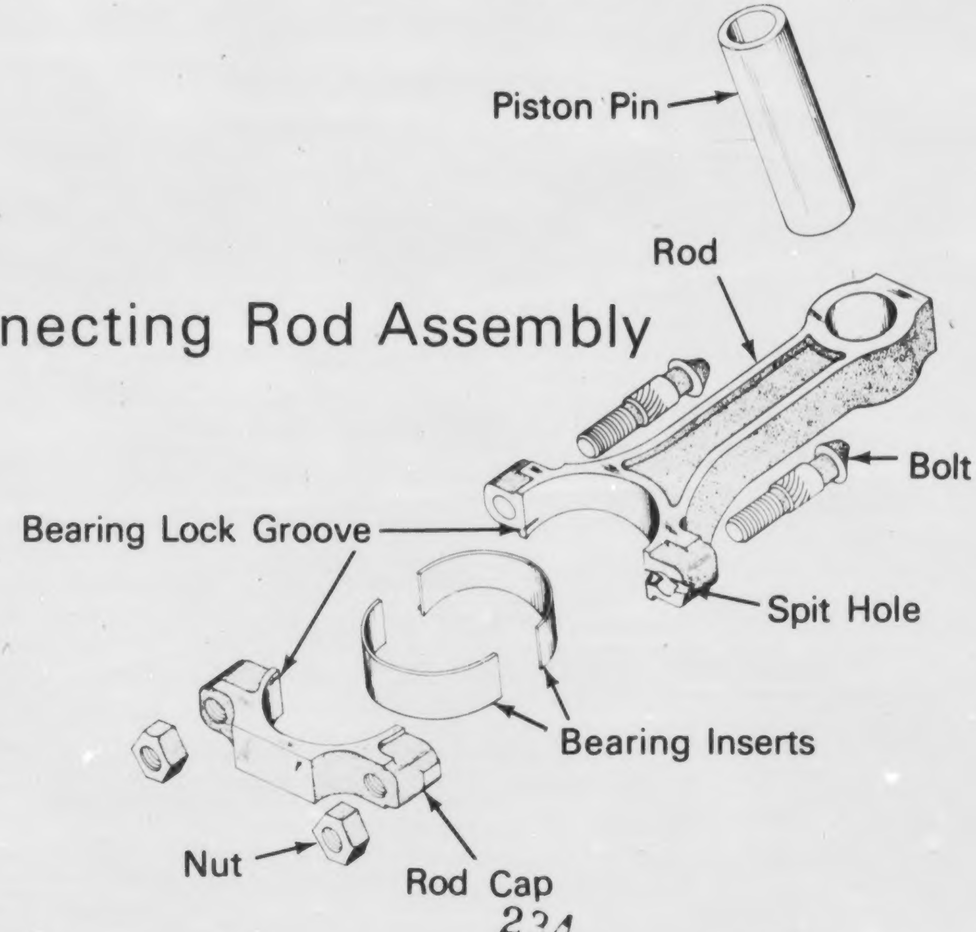
Expansion Disc Plug

Piston and Connecting Rod Assembly

Piston

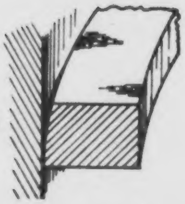

Ring Lands
Ring Grooves
Head
Heat Dam
Ring Section
Skirt Section
Pin Boss
Pin Bearing

Connecting Rod Assembly

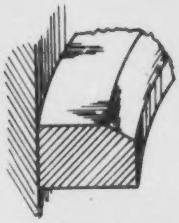

Piston Pin
Rod
Bolt
Bearing Lock Groove
Spit Hole
Bearing Inserts
Nut
Rod Cap

Types of Piston Rings

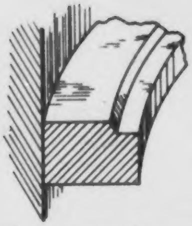
Compression Rings



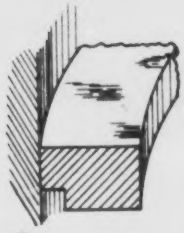
Tapered



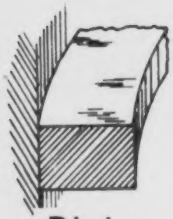
Chamfered



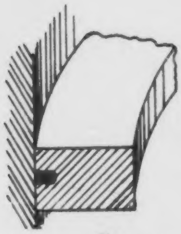
Counterbored



Scraper

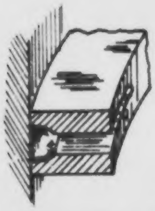


Plain

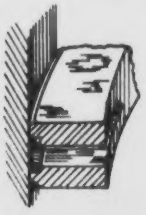


Center Grooved

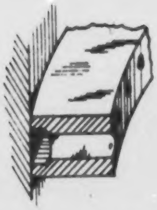
Oil Rings



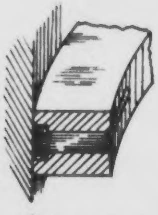
Radius Slotted



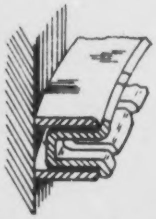
Wedge Slotted



Drilled



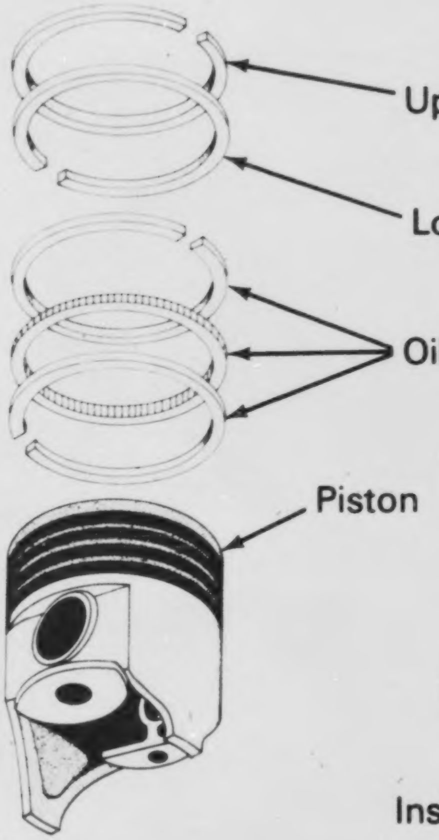
Slotted



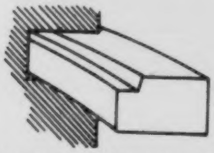
Three-piece

Methods of Installing Rings

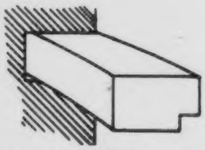
Oil Rings


Upper Compression Ring
Lower Compression Ring
Oil Ring Assembly
Piston

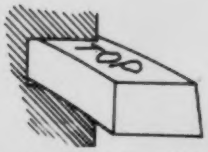
Compression Rings



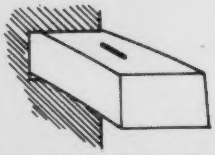
Install With Inside Groove Up



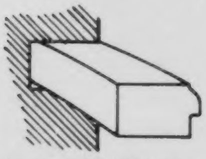
Install With Outside Groove Down



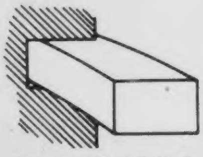
Install With Word "Top" Up



Install With Dash or Dot Up

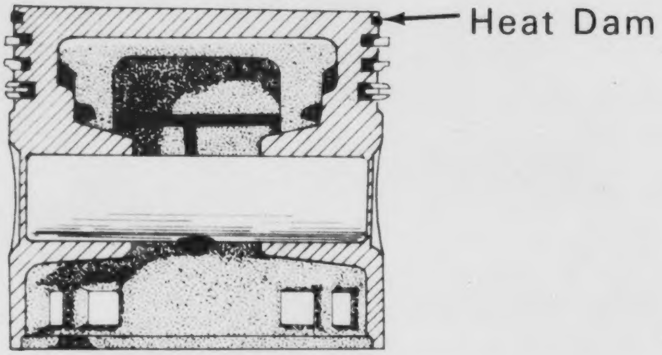


Install With Scraper Edge Down

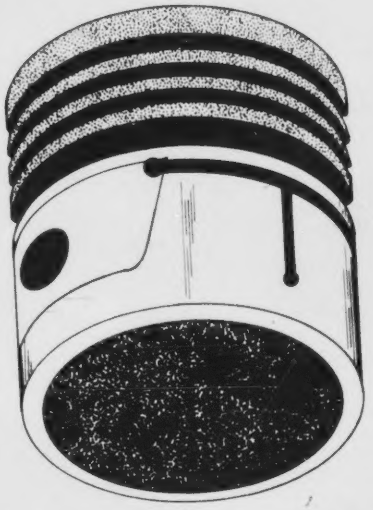


Install With Either Side Up

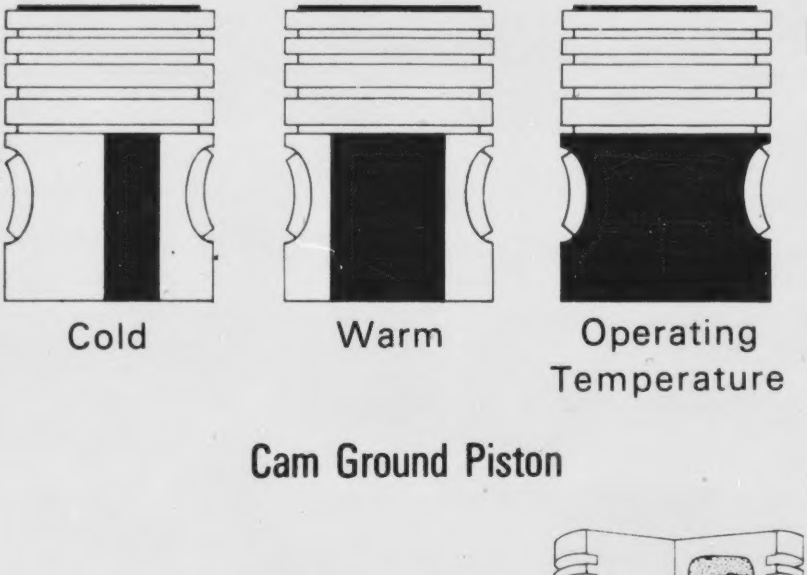
Methods of Heat and Expansion Control



Heat Dam



Horizontal or Vertical Slot

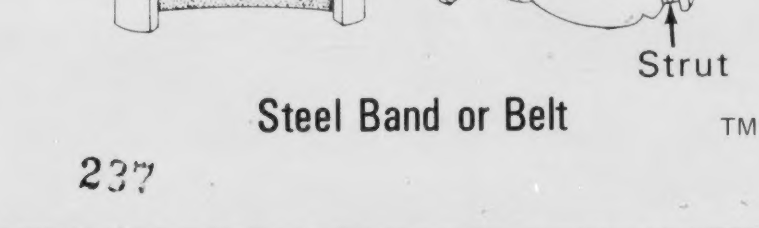


Cold

Warm

Operating Temperature

Cam Ground Piston

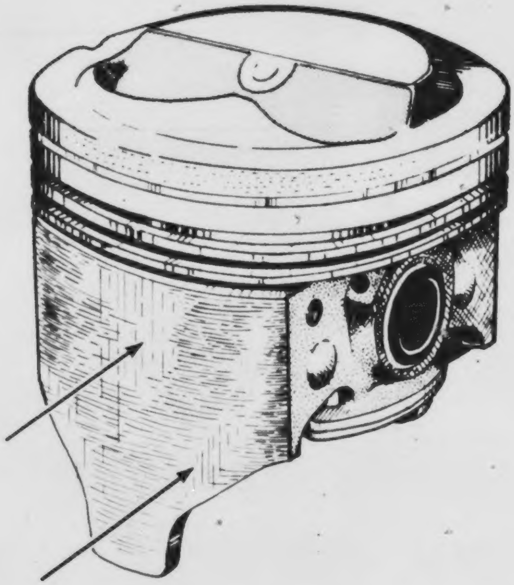


Steel Band or Belt

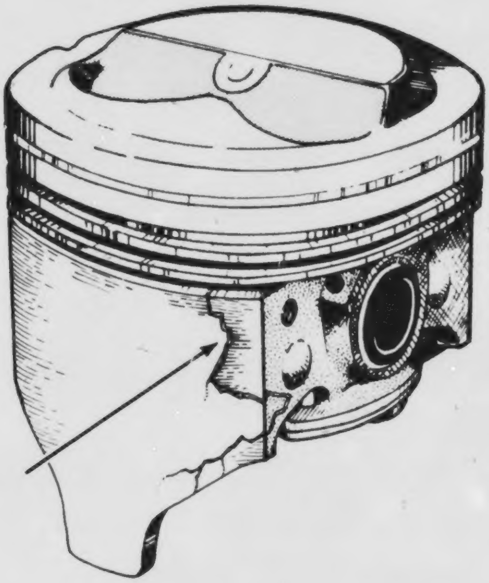
Piston Conditions and Related Causes

Piston Damage from Detonation

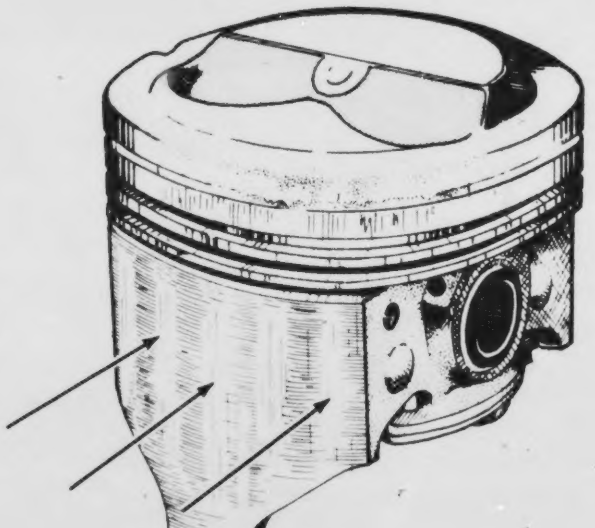
Normal Piston Skirt Wear



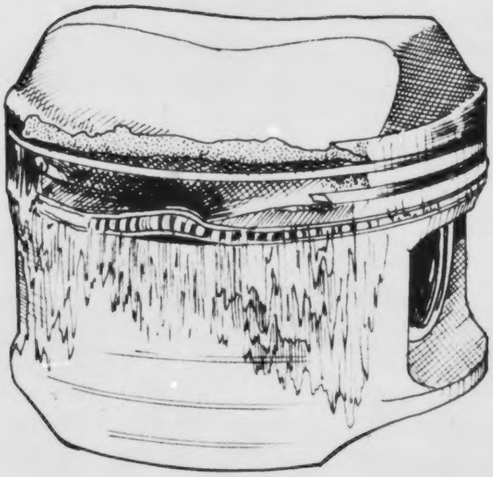
Cracked Piston



Moderate



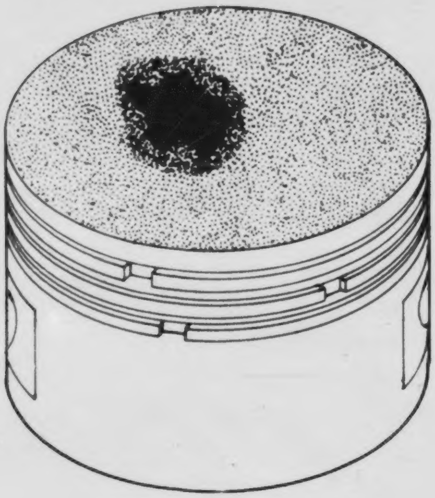
Severe



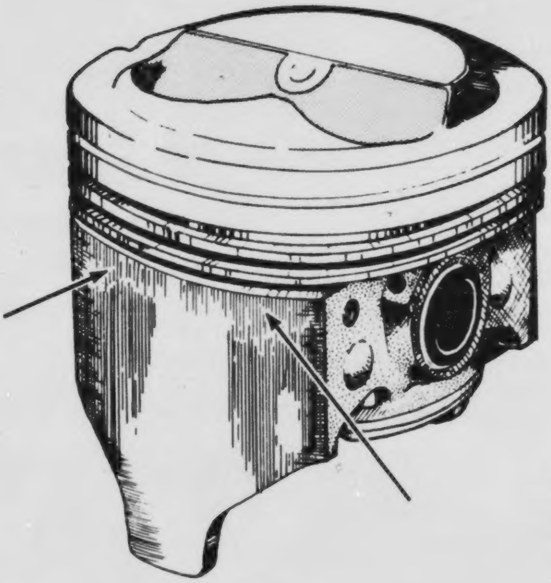
Piston Conditions and Related Causes

(Continued)

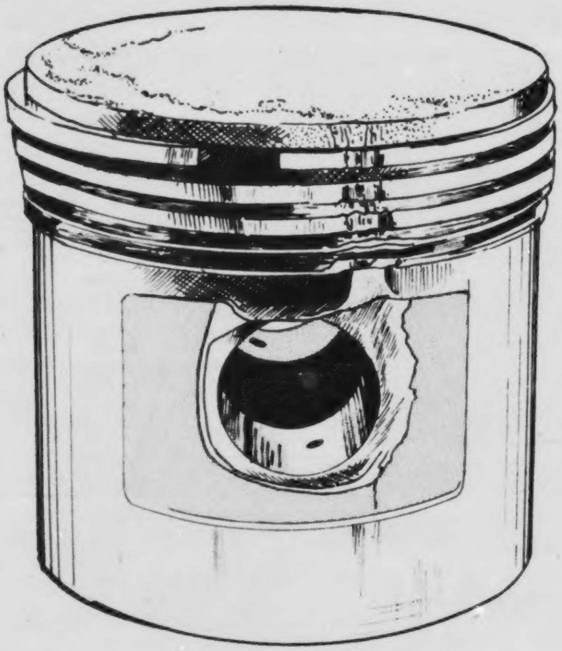
Piston Head Damage
From Pre-ignition



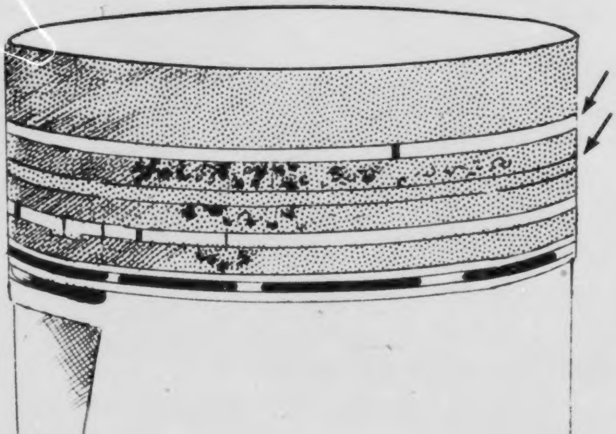
Skirt Wear Caused By A
Misaligned Connecting Rod



Damage Caused By A Loose
Piston Pin Lock Ring



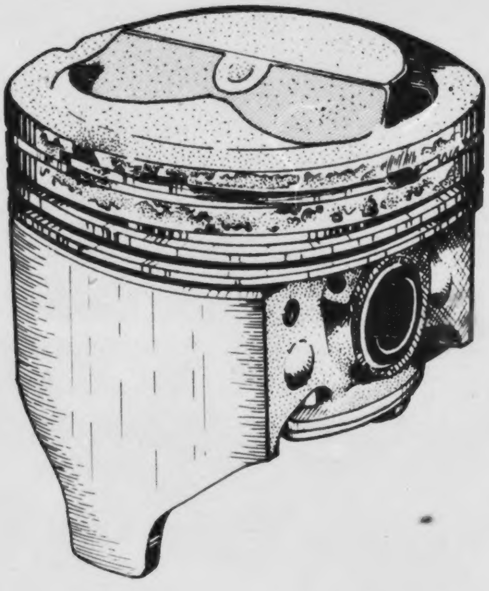
Piston Rings Stuck
In Their Grooves

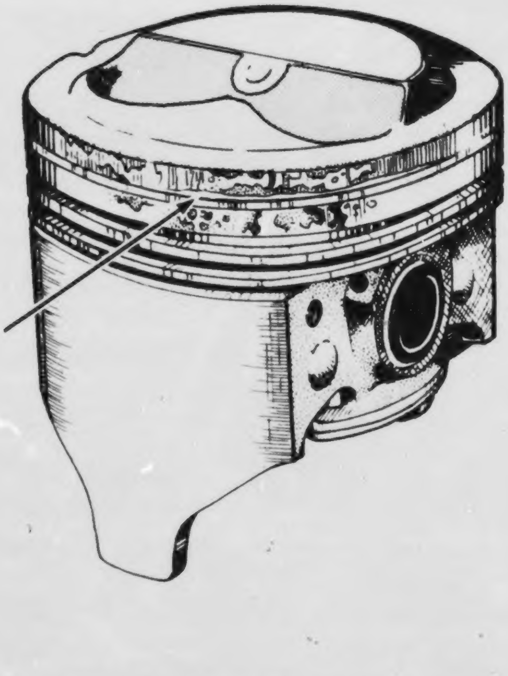


Piston Conditions and Related Causes

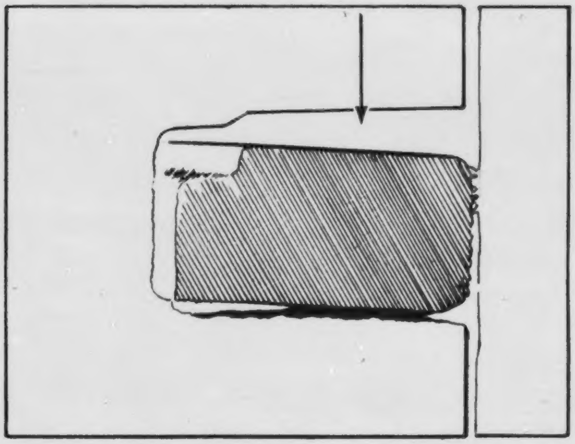
(Continued)

Damage Caused By A Broken Ring



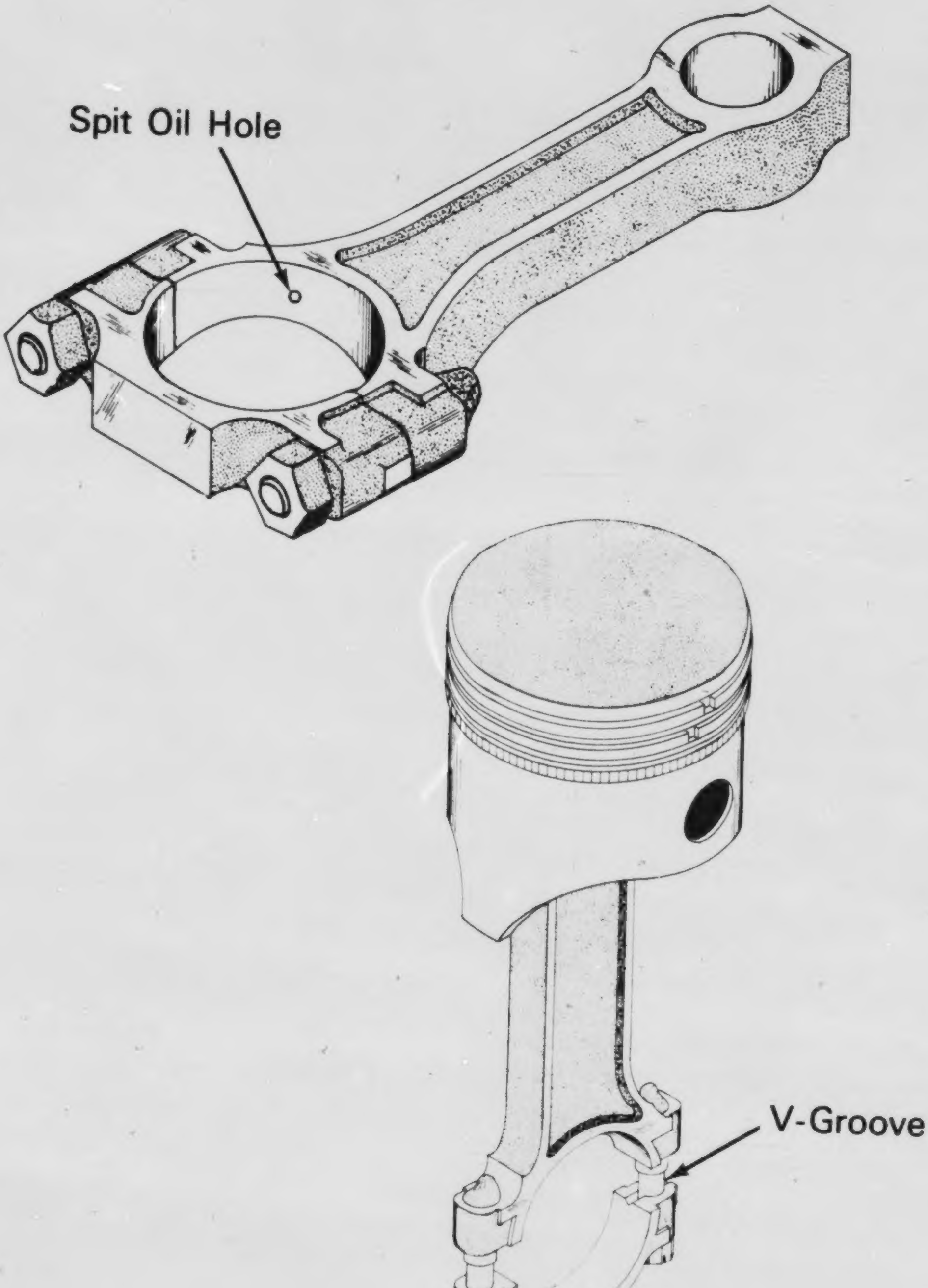


Side View of a Worn Upper Groove

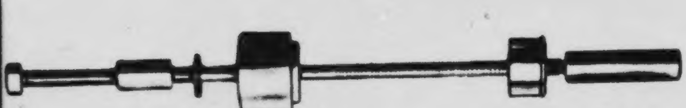


Cross Section of a Worn Upper Groove

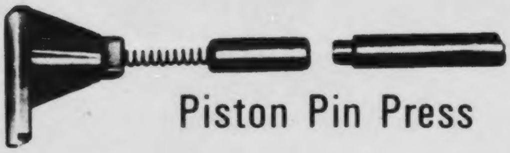
Cylinder Lubrication


Spit Oil Hole
V-Groove

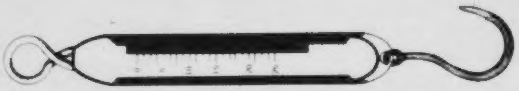
Special Tools Used For Cylinder and Piston Work



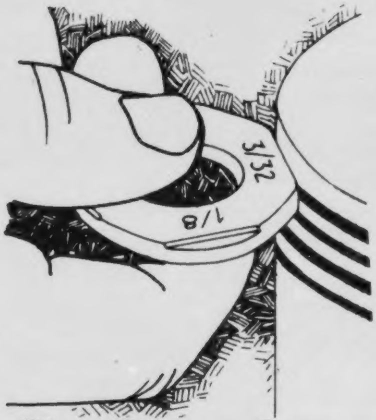
Sleeve Puller and Press



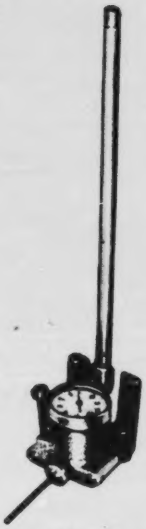
Piston Pin Press



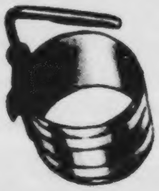
Piston Gauge and Scale



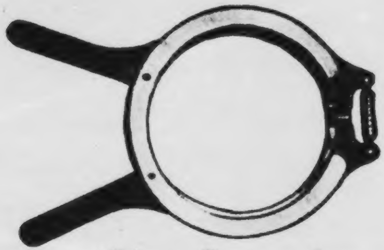
Ring Groove Gauge



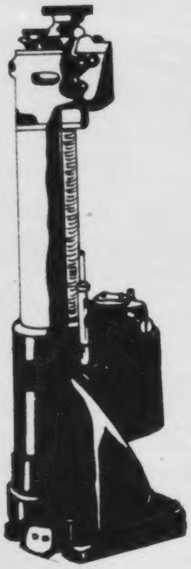
Cylinder Gauge



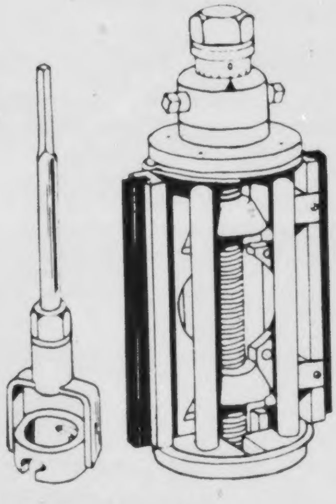
Ring Compressor



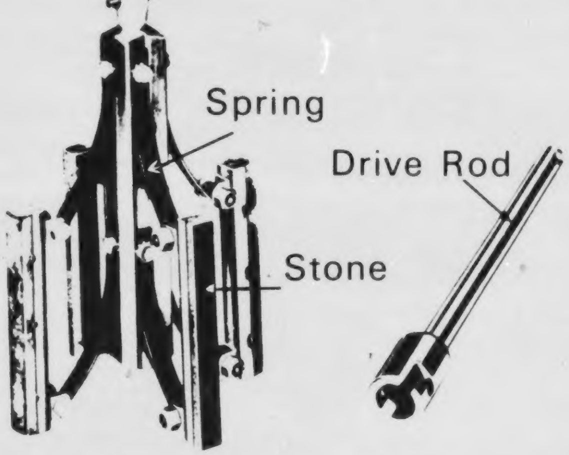
Ring Expander



Boring Bar

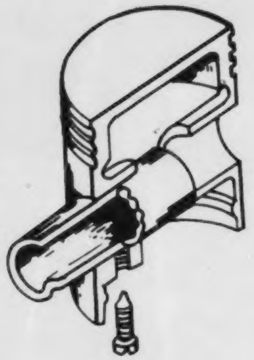


Boring Hone

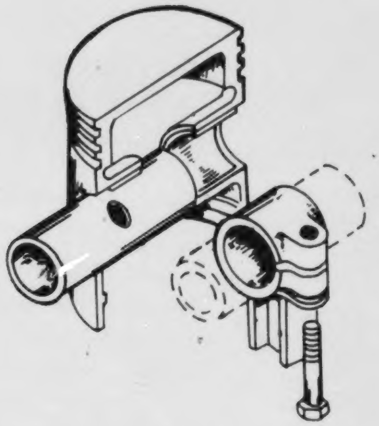

Spring
Drive Rod
Stone

Glaze Breaker Hone

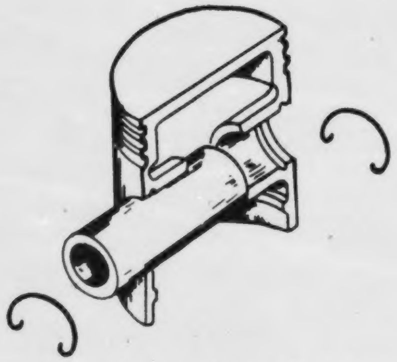
Types of Piston Pin Locks



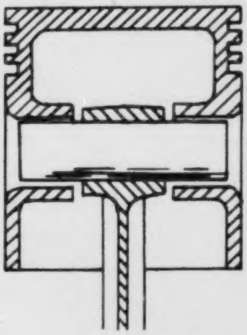
Locked to Piston



Locked to Connecting Rod



Free Floating



Press Fit in Rod

CYLINDER AND PISTON RECONDITIONING
UNIT VI

JOB SHEET #1--REMOVE PISTON RING RIDGE FROM CYLINDER

I. Tools and equipment

- A. Ridge remover tool
- B. Carbon scraper
- C. Safety glasses
- D. Basic hand tool set

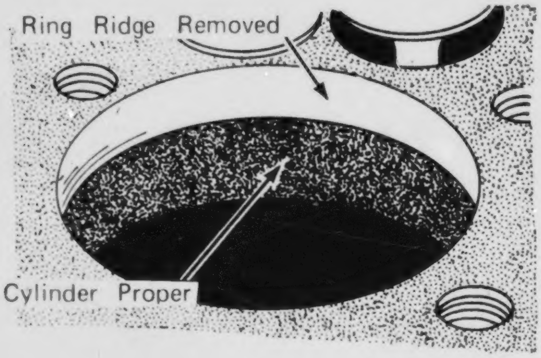
II. Procedure

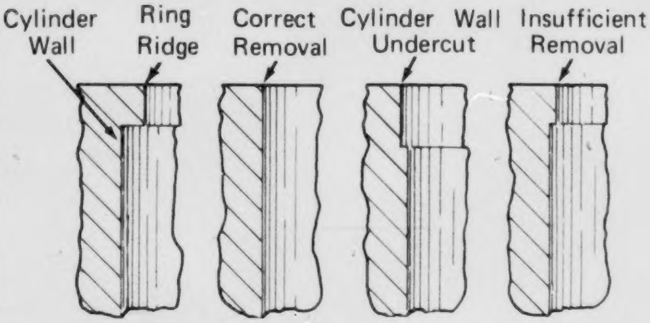
- A. Rotate the crankshaft until the piston is at bottom dead center
- B. Stuff a cloth into the cylinder on top of the piston

  (NOTE: The cloth is used to catch metal cuttings from the ridge remover tool.)

- C. Clean the carbon deposits off the ridge area

FIGURE 1


Ring Ridge Removed
Cylinder Proper


Cylinder Wall
Ring Ridge
Correct Removal
Cylinder Wall Undercut
Insufficient Removal

Ring Ridge Should Be Removed until Ridge Area Is Flush with the Cylinder Wall.

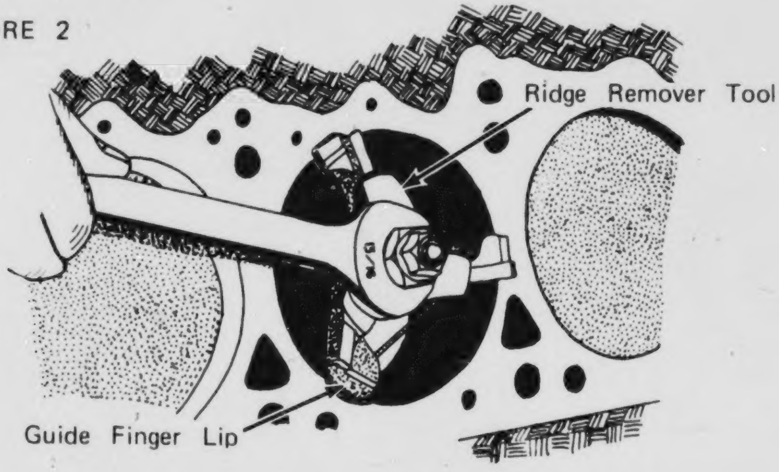
- D. Blow carbon from cylinder
- E. Wipe a film of light motor oil on cylinder walls
- F. Adjust the ridge remover tool to slightly smaller than the cylinder diameter

  (NOTE: There are several types of ridge remover tools. Be sure to read carefully and follow the instructions for the use of the particular tool.)

JOB SHEET #1

G. Place the ridge remover into the cylinder until it seats on its guides and adjust the cutting blade according to instructions (Figure 2)

FIGURE 2



H. Turn the ridge remover clockwise by hand to cut the ridge out

(CAUTION: Do not remove the ridge below the surface of the cylinder wall or scratch the cylinder wall where the piston ring travels.)

I. Remove the ridge remover from the cylinder

J. Remove the cloth from the cylinder

(NOTE: The piston can now be removed without damage to the ring lands.)

CYLINDER AND PISTON RECONDITIONING
UNIT VI

JOB SHEET #2--MEASURE A CYLINDER FOR TAPER, WEAR, AND OUT-OF-ROUND

I. Tools and equipment

- A. Cylinder gauge
- B. Micrometer set
- C. Clean shop towels
- D. Engine oil

II. Procedure

- A. Clean cylinder thoroughly
- B. Set up cylinder gauge (Figure 1)
  1. Attach handle and adjust so that the upper end swings over the meter
  2. Loosen the contact rod lock
  3. Adjust rod to slightly larger than cylinder diameter and lock

     (NOTE: Contact rod assortment may be stored in end of the handle.)
  4. Loosen gauge lock

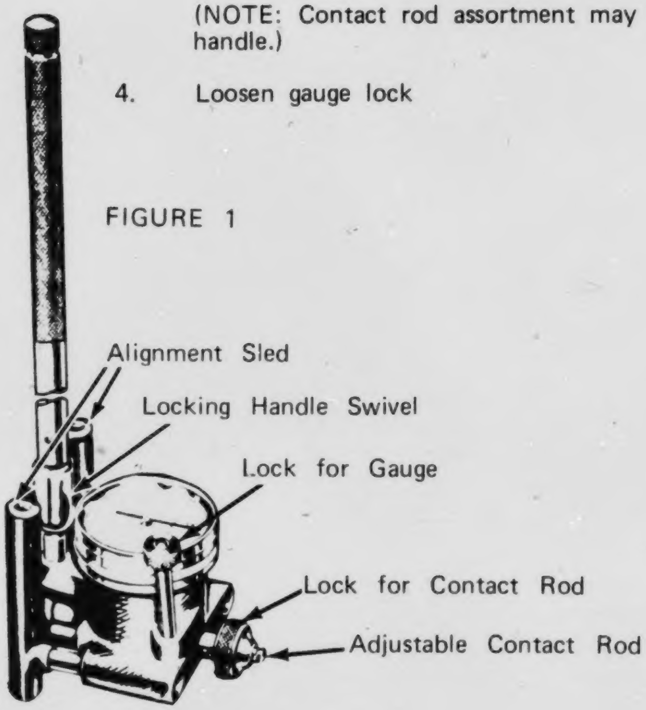


FIGURE 1

Alignment Sled
Locking Handle Swivel
Lock for Gauge
Lock for Contact Rod
Adjustable Contact Rod

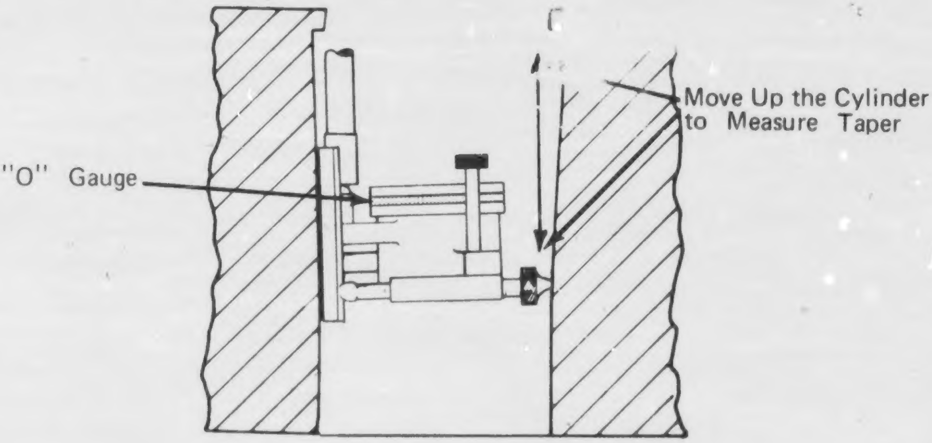
JOB SHEET #2

C. Check cylinder for taper (Figure 2)

1. Place gauge in cylinder
2. Align gauge in cylinder so that the gauge sled is contacting the cylinder wall the full length of both runners
3. Slide gauge down the cylinder until the contact rod is just at the lower piston ring travel
4. Adjust the dial to "0"
5. Move the gauge slowly up the cylinder until the contact rod is at the uppermost piston ring travel
6. Take meter reading

   (NOTE: This reading indicates the cylinder taper. Refer to manufacturer's specifications for allowable cylinder taper.)

FIGURE 2



JOB SHEET #2

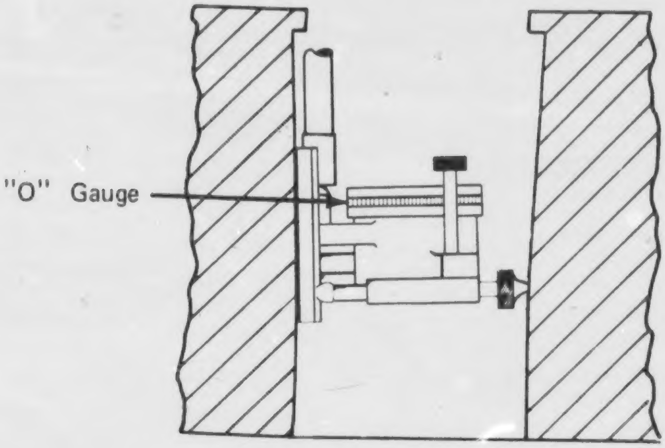
D. Check cylinder wear

1. Set gauge below lower piston ring travel

   (NOTE: This area will have very little if any cylinder wear so the gauge can be adjusted to original cylinder size at this position.)

2. Set dial to "0" (Figure 3)

FIGURE 3



3. Move gauge up the cylinder until it just reaches the uppermost piston ring travel

4. Take dial reading

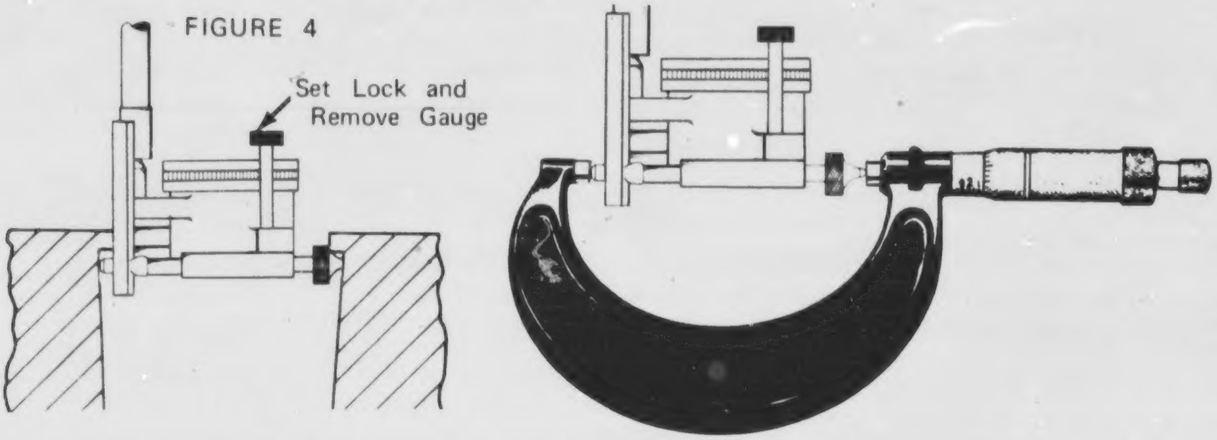
   (NOTE: Since the uppermost piston ring travel is the place of greatest wear, the gauge will read total cylinder wear. Refer to manufacturer's specifications for allowable cylinder wear.)

JOB SHEET #2

5. Set gauge lock and remove gauge from cylinder; measure worn diameter with a micrometer (Figure 4)

   (NOTE: Compare this reading with measurement of the piston skirt for piston clearance.)

FIGURE 4

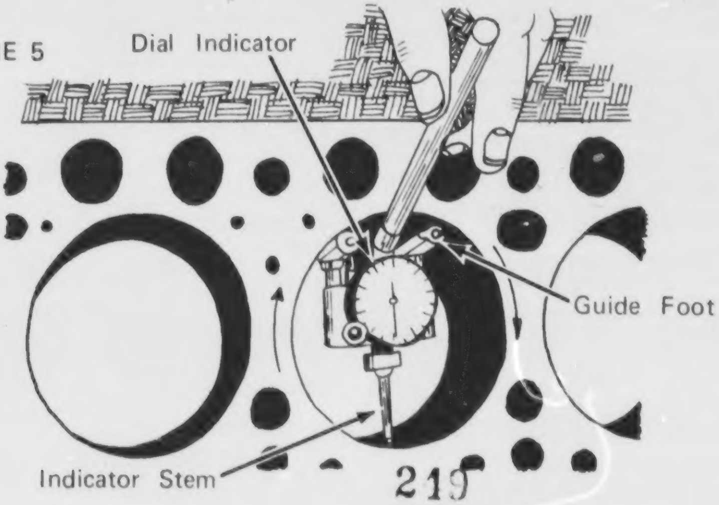


E: Check cylinder for out-of-round condition (Figure 5)

1. Position the gauge approximately halfway down the piston ring travel in the cylinder
2. Set dial to "0"
3. Rotate the gauge around the cylinder one complete turn, taking care to keep the gauge sled seated at all times

   (NOTE: The total variation of readings indicates the out-of-round condition of the cylinder. Refer to manufacturer's specifications for allowable variation.)

FIGURE 5



CYLINDER AND PISTON RECONDITIONING
UNIT VI

JOB SHEET #3--HONE A CYLINDER WITH A GLAZE BREAKER HONE

I. Tools and materials

   A. Glaze breaker hone

   B. Drill

   C. Cutting oil

   D. Detergent and water solution

   E. Safety glasses

   F. Scrub brush

II. Procedure

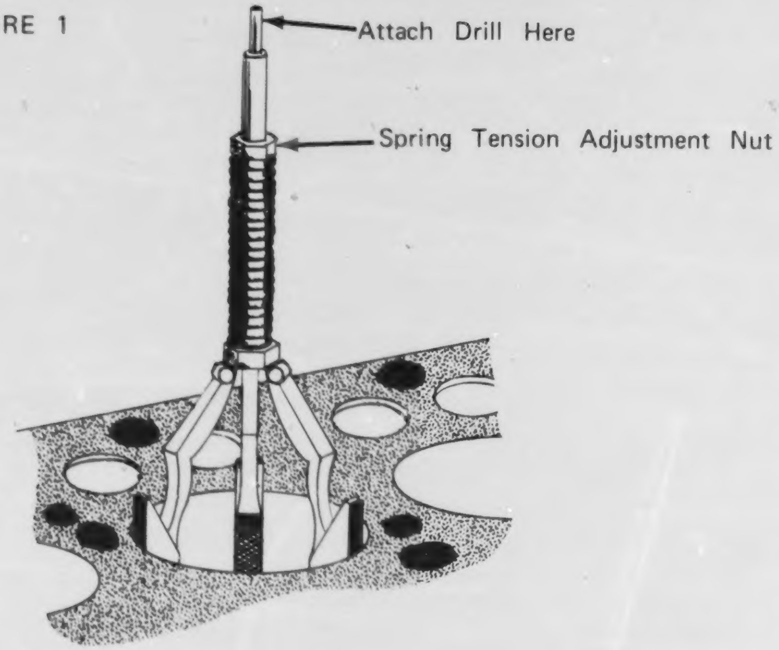
   A. Protect crankshaft and main bearings if shaft has not been removed

   B. Clean cylinder

   (NOTE: Ring ridge should have already been removed.)

   C. Place hone in cylinder and adjust spring tension to a light to medium load, if the hone is adjustable (Figure 1)

FIGURE 1



JOB SHEET #3

D. Connect drill motor to hone

(NOTE: A slower speed drill is desirable because it is easier to control the hone and obtain desired results.)

E. Remove the hone from the cylinder while being careful to collapse the stones away from the cylinder wall

F. Soak the hone and stones with cutting oil

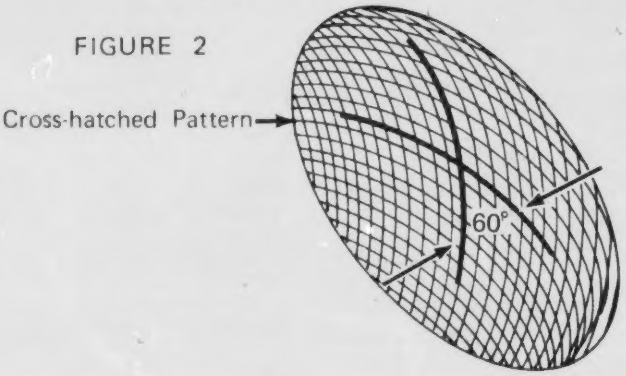
G. Reinstall hone into cylinder

H. Hold the hone and drill motor in alignment with the center line of the cylinder and switch on the motor

I. Move the hone up and down the cylinder at a rate that will produce a cross-hatched pattern on the cylinder wall (Figure 2)

(CAUTION: Do not let the hone travel too deep and catch in the main bearing webbing or come out of the top of the cylinder because the hone and operator both may receive severe damage.)

FIGURE 2



J. Hone the cylinder only enough to remove the glazed surface

K. Remove the hone

(NOTE: Be careful not to scrub the stone against the walls because it would cause vertical marks.)

L. Wash the cylinder walls thoroughly with soap, water, and scrub brush several times to remove all cuttings from the honing process

(CAUTION: Do not use solvent to clean cylinder walls.)

M. Dry the cylinder immediately and apply oil to the newly honed surface

CYLINDER AND PISTON RECONDITIONING
UNIT VI

JOB SHEET #4--CLEAN THE CYLINDER HEAD SURFACE AND CHECK FOR WARPAGE

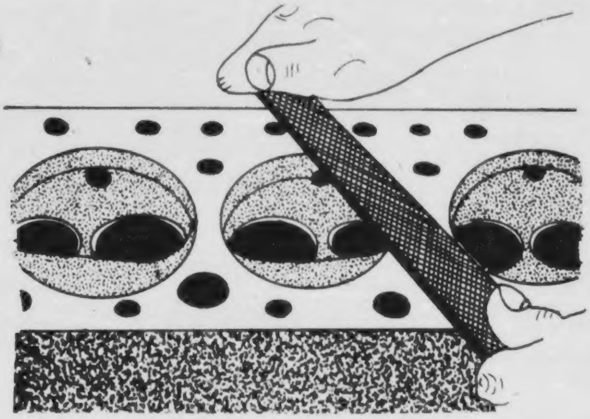
I. Tools and equipment

- A. Fine cut file (longer than block width)
- B. Straightedge
- C. Feeler gauge set, 0.001" to 0.006" (0.0254 mm - 0.1524 mm)
- D. Gasket scraper
- E. Safety glasses

II. Procedure

- A. Position cylinder block so that the head mating surface is almost horizontal
- B. Clean the surface with a gasket scraper
- C. Remove nicks on the cleaned surface with a fine cut file (Figure 1)

FIGURE 1



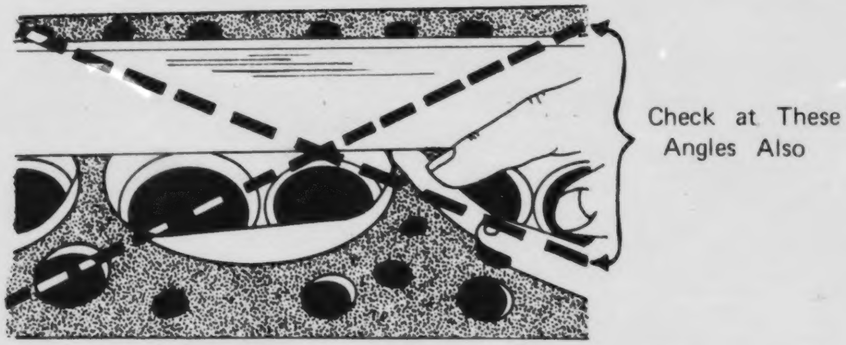
(NOTE: Make sure that only nicks are removed. The general condition of the surface should not be altered with a file.)

- D. Wipe the surface clean with a shop towel
- E. Position the straightedge lengthwise of the block

JOB SHEET #4

F. Check for warpage by placing a 0.001" (0.0254 mm) feeler gauge between the block and straightedge (Figure 2)

FIGURE 2



(NOTE: If at any position the gauge can be pulled from between the block and straightedge without dragging on the straightedge, try the next larger gauge. Continue until the gauge binds. If gauge thickness is more than 0.002" [0.0508 mm], the surface will require machining.)

G. Make several checks across the block lengthwise and crosswise

CYLINDER AND PISTON RECONDITIONING
UNIT VI

JOB SHEET #5--REMOVE AND REPLACE A CYLINDER BLOCK CORE PLUG

I. Tools and equipment

   A. Hammer

   B. Pointed pry bar

   C. Nonhardening sealer

   D. Driving tool to fit core plug size

   E. Safety glasses

   F. Wire brush

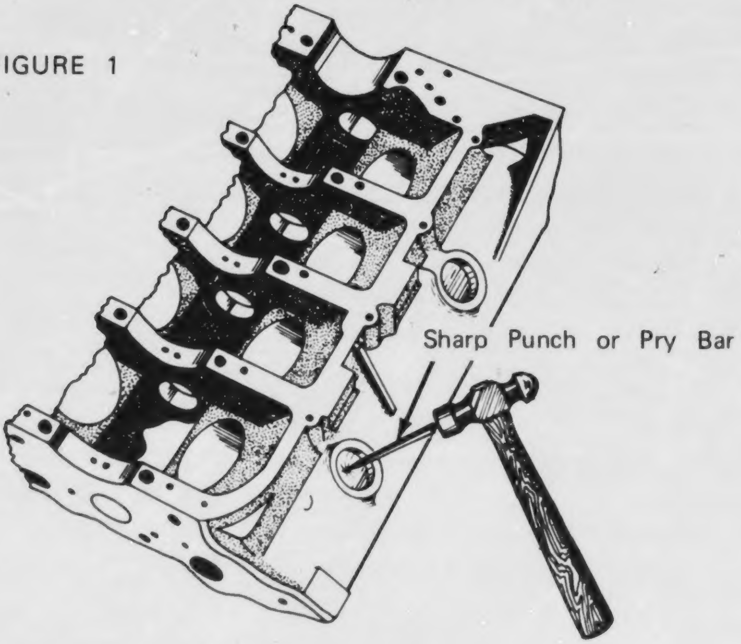
II. Procedure

   A. Remove the old core plug

      1. Drive the sharp end of the pry bar through the center of the plug

      2. Pry the plug out with the bar (Figure 1)

FIGURE 1


Sharp Punch or Pry Bar

JOB SHEET #5

B. Clean the sediment from the water jacket behind the plug hole

C. Clean the sealing surface of the core hole with a wire brush or other appropriate tool

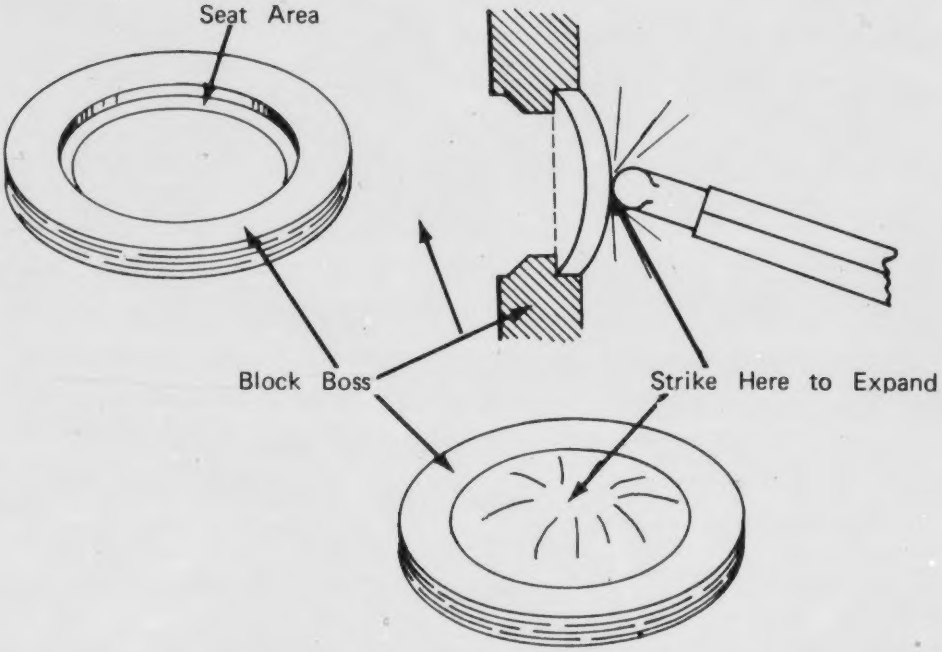
D. Coat the sealing edge of the new core plug with a nonhardening sealer

E. Place the core plug in the hole in the block

F. Drive the plug into place with the appropriate driver

(NOTE: On the expansion disc type plug, place the plug in the hole against the seat and then expand the plug by striking the plug in the center with a flat-faced punch to partially remove the cup shape of the plug. See Figure 2.)

FIGURE 2



CYLINDER AND PISTON RECONDITIONING
UNIT VI

TEST

NAME________________________________ SCORE ______________

1. Match the terms on the right to the correct definitions.

______a. Combustion gases that slip past the piston and rings to get into the crankcase

______b. Chamber between the cylinder bores on a V-block engine

______c. To size a hole to exact dimensions with a cutting tool called a *reamer*

______d. Expandable rotating tool with abrasive fingers turned by an electric motor; used to clean and smooth the inside surface of a cylinder

______e. That portion of the cylinder above the top limit of ring travel

______f. To roughen the surface of a piece of metal by pressing a series of cross-hatched lines into the surface and thereby raising the area between these lines

______g. Sound made by a piston with excess skirt clearance as the crankshaft goes across top center

______h. Diameter of an engine cylinder

______i. Basic framework of the engine to which the other engine parts are attached

______j. Large diameter portion between piston ring grooves

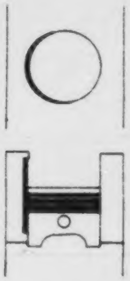
______k. Raised portion of a piston head

______l. Lower ring or rings on a piston; designed to prevent excessive amounts of oil from working up into the combustion chamber

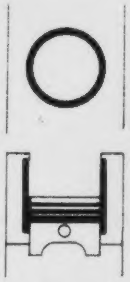
______m. Special tool used to expand piston rings for installation on the piston

1. Pop-up
2. Blow-by
3. Piston slap
4. Knurl
5. Oil control ring
6. Ream
7. Lands
8. Ring ridge
9. Lifter valley
10. Cylinder hone
11. Ring expander tool
12. Bore
13. Cylinder block

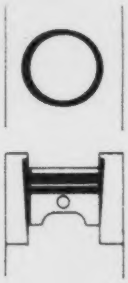
2. Identify the cylinder wear patterns by writing the correct conditions in the blanks provided.



a. ____________________



b. ____________________



c. ____________________

3. List the three methods of reconditioning cylinders.

a. ____________________

b. ____________________

c. ____________________

4. Name two types of cylinder sleeves.

a. ____________________

b. ____________________

5. Discuss the reason that cylinders taper as they wear.

____

____

____

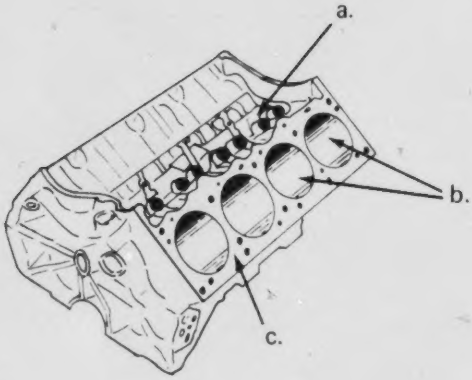
____

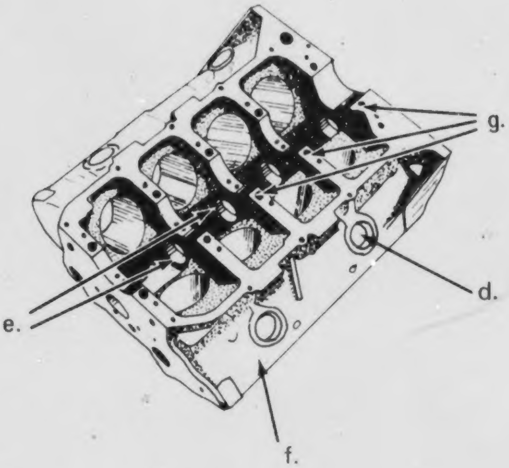
____

____

____

6. Identify the parts of the cylinder block by writing the correct names in the blanks.





a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

g. ____________________

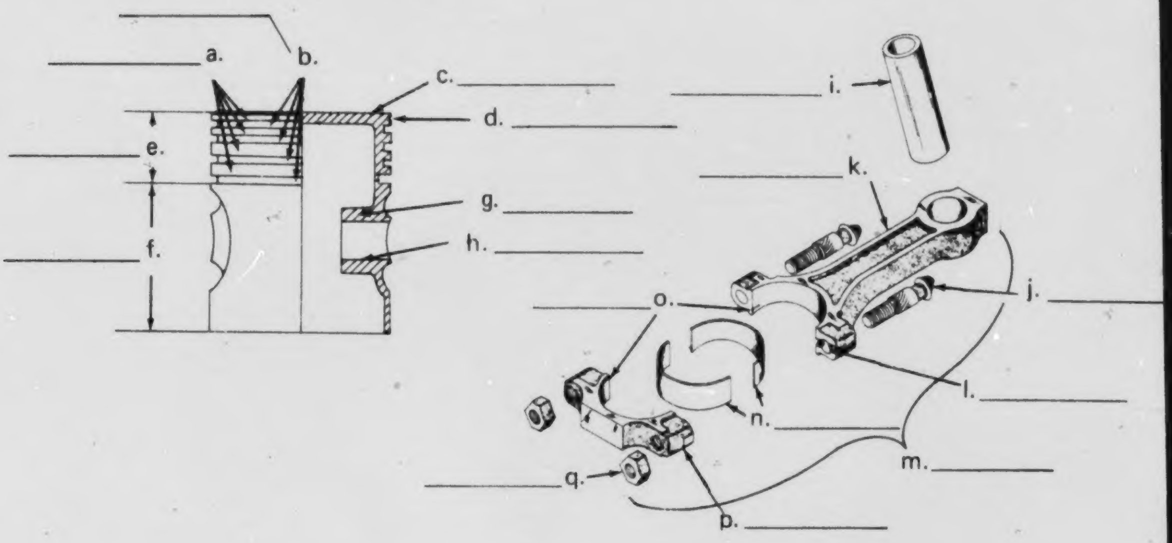
7. Name three types of cylinder block core hole plugs.

a. ____

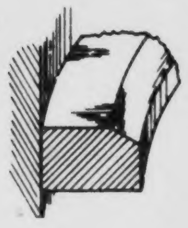
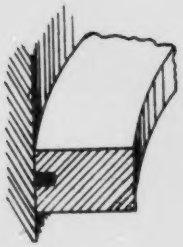
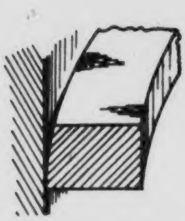
b. ____

c. ____

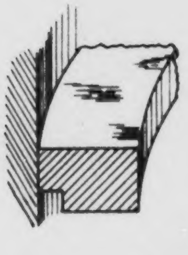
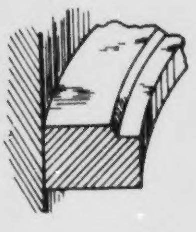
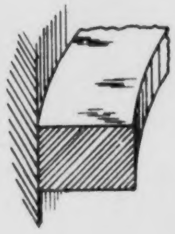
8. Identify the parts of the piston and connecting rod assembly below by writing the correct names in the blanks provided.



9. Identify the following types of compression rings by writing the correct names in the blanks provided.

a. ____________ b. ____________ c. ____________

d. ____________ e. ____________ f. ____________

10. Match the compression rings on the right to the correct method of installation.

______a. Inside groove up

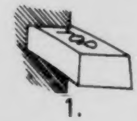
______b. Word *TOP* up

______c. Scraper edge down

______d. Outside groove down

______e. Dash or dot up

______f. Either side up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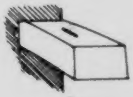
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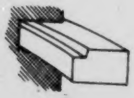
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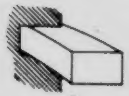
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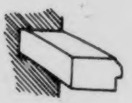
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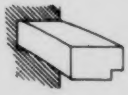
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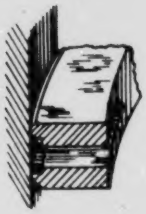
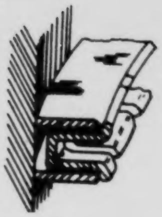
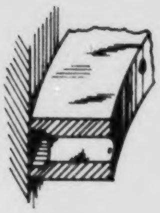
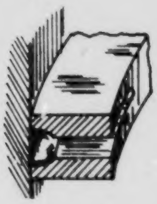
11. Identify the following types of oil rings.

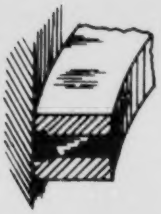




a. ______________________ b. ______________________







c. ______________ d. ______________ e. ______________

12. List the methods for installing the following types of oil rings.

a. One-piece--______________________________

b. Two-piece--______________________________

c. Three-piece--______________________________

____

____

13. Match the methods of heat and expansion control in a piston on the right to the correct descriptions.

______a. Groove around the top of the piston that reduces the flow of heat from the piston head to the piston skirt

______b. T-shaped slot that breaks the path of heat traveling to the skirt and allows for skirt expansion without increasing diameter

______c. Piston skirt is ground to a cam shape and contacts only in the center when it is cold; as it heats up it becomes round to fit the cylinder more completely

______d. Steel band cast into the piston pin boss that reduces expansion of the piston skirt due to heat and conducts heat out through pin boss

1. Cam ground piston
2. Heat dam
3. Steel band or belt
4. Horizontal or vertical slot in piston skirt

14. Match the piston conditions on the right to the correct causes.

______a. Pre-ignition or overheated cylinder

______b. Poor maintenance, poor air filtration, or service abuse

______c. Misaligned connecting rod

______d. Cylinder detonation

______e. Broken piston ring and pre-ignition

______f. Excessive carbon deposit buildup

______g. Piston improperly fitted to cylinder

______h. Loose or broken piston pin lock ring

1. Cracked piston skirt
2. Moderate and severe skirt damage
3. Piston head damage
4. Piston skirt wear
5. Piston pin boss and ring land damage
6. Piston rings stuck in groove
7. Ring land damage
8. Excessively worn upper ring groove

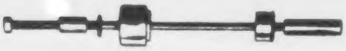
15. List three methods of lubricating cylinder walls and piston pins.

a. ______________________________

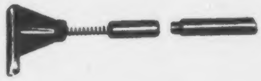
b. ______________________________

c. ______________________________

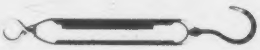
16. Identify the following tools and equipment used in reconditioning cylinders and pistons.



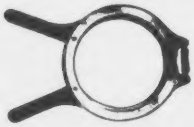
a. ____________________



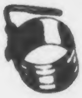
b. ____________________



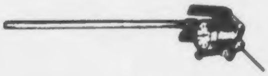
c. ____________________



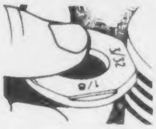
d. ____________________



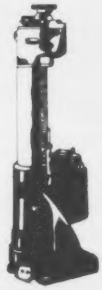
e. ____________________



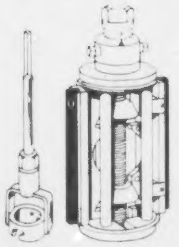
f. ____________________



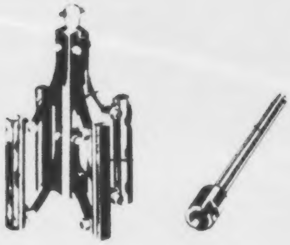
g. ____________________



h. ____________________

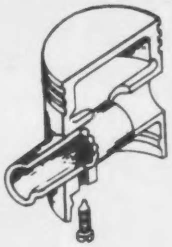


i. ____________________

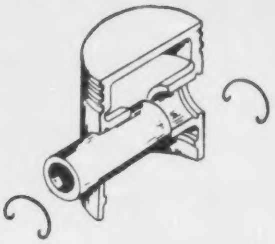


j. ____________________

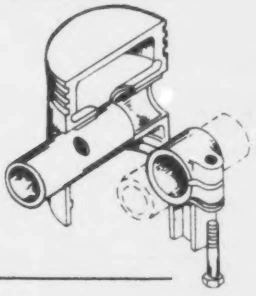
17. Identify the following types of piston pin locks.



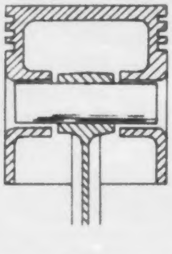
a. ____________________



b. ____________________



c. ____________________



d. ____________________

18. Demonstrate the ability to:

a. Remove piston ring ridge from cylinder.

b. Measure a cylinder for taper, wear, and out-of-round.

c. Hone a cylinder with a glaze breaker hone.

d. Clean the cylinder head surface and check for warpage.

e. Remove and replace a cylinder block core plug.

(NOTE: If these activities have not been accomplished prior to the test, ask the instructor when they should be completed.)

CYLINDER AND PISTON RECONDITIONING
UNIT VI

ANSWERS TO TEST

1. a. 2
   b. 9
   c. 6
   d. 10
   e. 8
   f. 4
   g. 3
   h. 12
   i. 13
   j. 7
   k. 1
   l. 5
   m. 11

2. a. Out of round
   b. Wear
   c. Taper

3. a. Hone
   b. Bore
   c. Sleeve

4. a. Dry
   b. Wet

5. Discussion should include:

   a. Cylinder pressure is created during compression and power stroke in the ring grooves and behind the ring, forcing the ring against the bottom of the groove and out against the cylinder wall

   b. Since the greater pressure is created when the piston is at the top of the cylinder, the rings create more wear at the top of the cylinder

   c. Less lubricating oil reaches the upper cylinder area, increasing friction

   d. More heat is concentrated in the upper cylinder area due to the burning fuel

6. a. Valve lifter chamber
   b. Cylinders
   c. Head mating surface
   d. Core hole

e. Camshaft bore
f. Water jacket
g. Main bearing support

7. a. Cup
b. Expansion cup
c. Expansion disc

8. a. Ring lands
b. Ring grooves
c. Head
d. Heat dam
e. Ring section
f. Skirt section
g. Pin boss
h. Pin bearing
i. Piston pin
j. Bolt
k. Rod
l. Spit hole
m. Connecting rod assembly
n. Bearing insert
o. Bearing lock groove
p. Rod cap
q. Nut

9. a. Chamfered
b. Center grooved
c. Tapered
d. Scraper
e. Counterbored
f. Plain

10. a. 3
    b. 1
    c. 5
    d. 6
    e. 2
    f. 4

11. a. Wedge slotted
    b. Three-piece
    c. Drilled
    d. Radius slotted
    e. Slotted

12. a. Either side up
    b. Expander gap 180° from ring gap
    c. Expander with ends butted together and steel rail gaps 180° apart and 90° from expander gap

13. a. 2
    b. 4
    c. 1
    d. 3

14. a. 3
    b. 8
    c. 4
    d. 2
    e. 7
    f. 6
    g. 1
    h. 5

15. a. Splash system
    b. Spit oil hole in rod
    c. V-groove in rod

16. a. Sleeve puller and press
    b. Piston pin press
    c. Piston gauge and scale

d. Ring expander

e. Ring compressor

f. Cylinder gauge

g. Ring groove gauge

h. Boring bar

i. Boring hone

j. Glaze breaker hone

17. a. Locked to piston

b. Free floating

c. Locked to connecting rod

d. Pressed in rod

18. Performance skills evaluated to the satisfaction of the instructor

ENGINE REASSEMBLY
UNIT VII

UNIT OBJECTIVE

After completion of this unit, the student should be able to assemble and adjust all parts and components in an automobile engine. The student should be able to assemble the engine, observing all safety precautions as well as maintaining a clean and orderly work area. This knowledge will be evidenced through demonstration and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with engine reassembly to the correct definitions.
2. Identify tools used in engine reassembly.
3. List reasons for torqueing bolts to specifications in an engine.
4. Demonstrate the ability to:
    a. Install camshaft and bearings.
    b. Install crankshaft, bearings, timing gears, and timing cover.
    c. Install pistons and connecting rod assemblies.
    d. Install oil pump, pickup screen, and oil pan.
    e. Install cylinder head, intake manifold, and exhaust manifold.
    f. Install engine accessory components.

ENGINE REASSEMBLY
UNIT VII

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

  A. Provide student with objective sheet.

  B. Provide student with information and job sheets.

  C. Make transparencies.

  D. Secure materials and equipment for job sheet demonstrations.

  E. Discuss unit and specific objectives.

  F. Discuss information sheet.

  G. Demonstrate and discuss procedures outlined on the job sheets.

  H. Evaluate student performance on job sheets.

  I. Give test.

II. Unit references:

  A. Crouse, William H. *Automotive Engine Design.* New York: McGraw-Hill Book Co., 1970.

  B. Crouse, William H. *Automotive Mechanics.* 7th ed. New York: McGraw-Hill Book Co., 1975.

  C. Ellinger, Herbert E. *Automechanics.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1972.

  D. *Chevrolet Service Manual.* Detroit, Michigan: Chevrolet Motor Div./General Motors Corp., 1977.

  E. *Chrysler, Plymouth, Dodge Chassis Service Manual.* Detroit, Michigan: Chrysler Corp., 1976.

  F. *Ford Service Manual.* Dearborn, Michigan: Ford Motor Co., 1975-76.

ENGINE REASSEMBLY
UNIT VII

INFORMATION SHEET

I. Terms and definitions

  A. Torque sequence--Tightening pattern that draws two components together evenly at all points

  B. Tolerance--Variation of the fit or adjustment of two related working parts

  C. Lubriplate--Lithium-based lubricant with high impact and temperature stability qualities

  D. Gasket--Flat strip, usually of cork or metal or both, placed between two machined surfaces to provide a tight seal

  E. TDC (top dead center)--Position of piston at its highest travel in the cylinder

II. Tools used in engine reassembly (Transparency 1)

  A. Camshaft bearing remover and installer tool set

  B. Ring compressor

  C. Ring expander

  D. Rear main bearing seal tool

  E. Torque wrench

  F. Vibration damper tool

  G. Push rod installing tool

  H. Valve lifter installing tool

  I. Piston pin press

III. Reasons for torqueing bolts to specifications in an engine

  A. To prevent overtightening and stretching of bolts

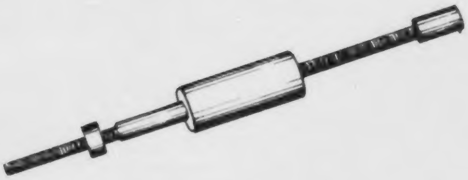
  B. To prevent distortion of the mating surfaces between the parts

  C. To prevent thread damage

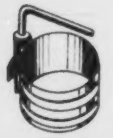
  D. To prevent leaks from uneven mating surfaces

  E. To prevent cylinder wall distortion from overtightened head bolts

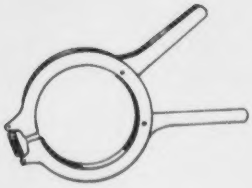
Tools Used for Engine Reassembly



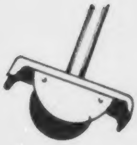
Camshaft Bearing Removing and Installing Tool



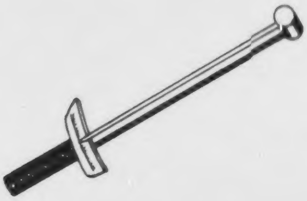
Ring Compressor



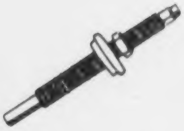
Ring Expander



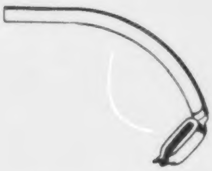
Rear Main Bearing Seal Installer



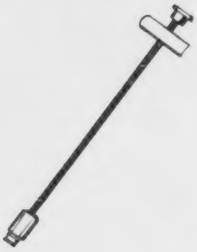
Torque Wrench



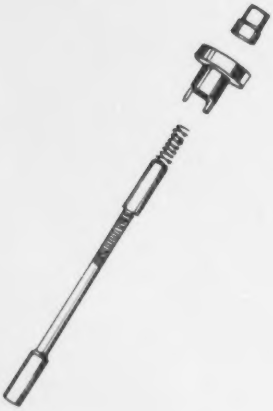
Vibration Damper Tool



Push Rod Installer Tool



Valve Lifter Installing Tool



Piston Pin Press

ENGINE REASSEMBLY
UNIT VII

JOB SHEET #1--INSTALL CAMSHAFT AND BEARINGS

I. Tools and equipment

   A. Cam bearing remover and installer tool

   B. Basic hand tool set

   C. Safety glasses

   D. Clean shop towels

   E. Lubriplate

II. Procedure

   A. Position cylinder block on a low workbench so that the crankshaft chamber is facing up (Figure 1)

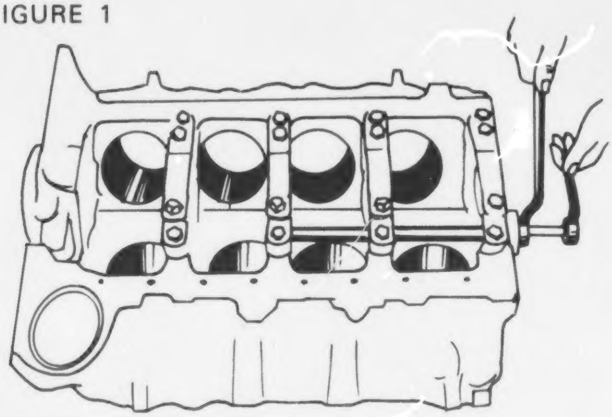
   B. Remove old cam bearings

      1. Select the correct size of puller adapter for each bearing

         (NOTE: One adapter may fit all bearings, but be sure it fits so cylinder block will not be damaged.)

      2. Pull the inside bearings first and then the outside bearings

FIGURE 1



(NOTE: Keep the old bearings marked for correct positioning in the bore and for correct location to help install the new bearings.)

JOB SHEET #1

C. Clean bearing bores

D. Clean oil delivery passages with a bristled brush and compressed air

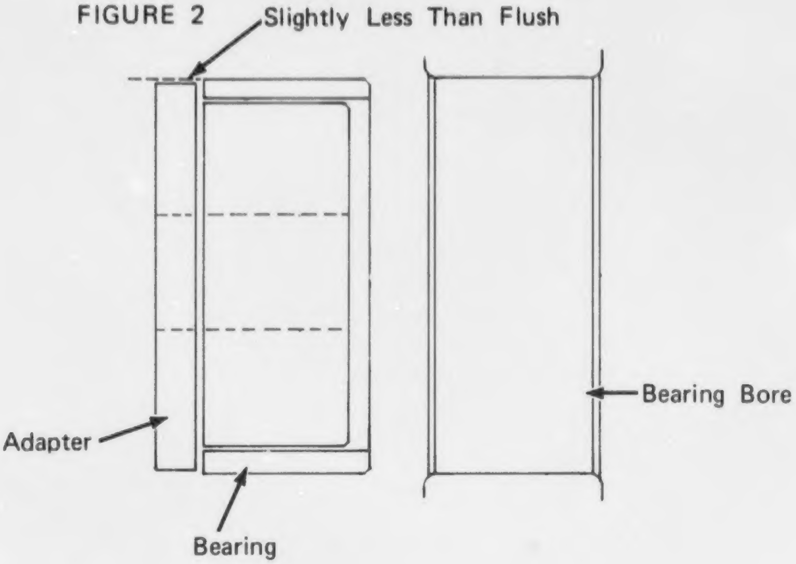
E. Install new camshaft bearings

1. Lay out cam bearings on the cylinder block in order of installation

2. Position the bearing on the installer adapter

   (NOTE: Be sure the lip of the adapter catches fully on the bearing edge, but moves freely through the cylinder block bearing bore. See Figure 2.)

FIGURE 2



3. Place the assembled adapter and bearing in the cylinder block cavity for the camshaft next to the bearing bore (Figure 3)

4. Mark position of oil hole on block next to bearing bore for easy bearing alignment as it is installed (Figure 3)

5. Install the puller shaft into the camshaft bearing bores (Figure 3)

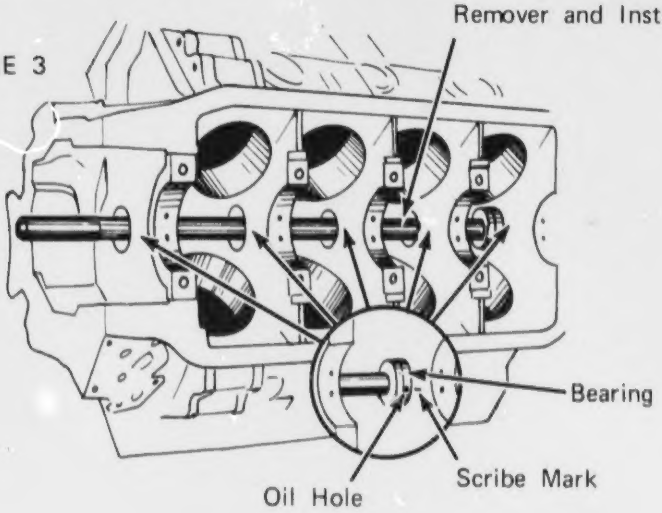
6. Attach puller shaft to bearing installer adapter (Figure 3)

JOB SHEET #1

7. Install the bearing while aligning the oil hole with the alignment mark

   (NOTE: The bearing oil holes should align with block oil holes and the bearing should not stick out past the block on either side.)

FIGURE 3

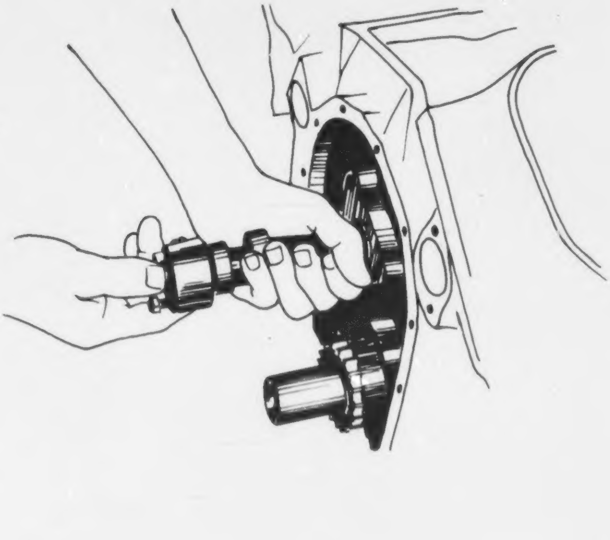

Remover and Installer
Bearing
Scribe Mark
Oil Hole

8. Install the remaining bearings using the same procedure

F. Lubricate cam bearings with lubriplate

G. Install camshaft, being careful not to scratch the soft bearing surface with the camshaft lobes

FIGURE 4



JOB SHEET #1

H. Rotate the shaft slowly and coat the cam lobes with lubriplate

(NOTE: Some camshaft manufacturers provide a special lubricant for the camshaft lobes. This lubricant should be used instead of lubriplate if it is available.)

ENGINE REASSEMBLY
UNIT VII

JOB SHEET #2--INSTALL CRANKSHAFT, BEARINGS, TIMING GEARS, AND TIMING COVER

I. Tools and equipment

   A. Torque wrench

   B. Basic hand tool set

   C. Plastigauge

   D. New main bearing set

   E. Safety glasses

   F. Engine repair stand

   G. Gasket sealer

   H. Lubriplate

II. Procedure

   (NOTE: The engine can be mounted on the engine repair stand prior to this job sheet.)

   A. Clean the oil passages with compressed air

   B. Clean the main bearing seat areas in the block

   C. Install the main bearings in the block

      (NOTE. Refer to Figure 1 on the following page.)

      1. Align bearing tang with recess in block

      2. Check alignment of bearing oil hole with block oil hole

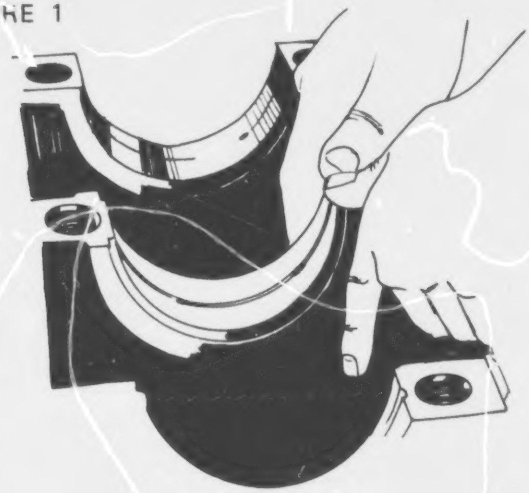
      3. Press bearing shell in place firmly

JOB SHEET #2

4. Center the bearing in the block

(NOTE: Use extra care in seating the thrust bearing properly.)

FIGURE 1



D. Wipe bearings clean

E. Blow out oil passages in crankshaft

F. Clean crankshaft main bearing journals

G. Install the crankshaft in the cylinder block

(NOTE: The shaft must be laid in the bearings gently and evenly or it will bind on the bearings and may cause damage.)

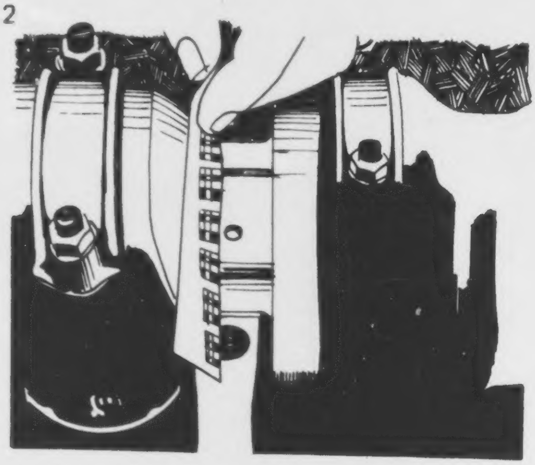
H. Install bearing in main bearing cap

JOB SHEET #2

I. Gauge the bearing clearance with plastigauge (Figure 2)

(NOTE: Compare the gauge clearance with manufacturer's specifications.)

FIGURE 2



J. Clean plastigauge from crankshaft journals and bearings

K. Remove crankshaft

L. Install rear main bearing oil seal

M. Lubricate bearings in cylinder block

N. Lubricate the bearings in the caps

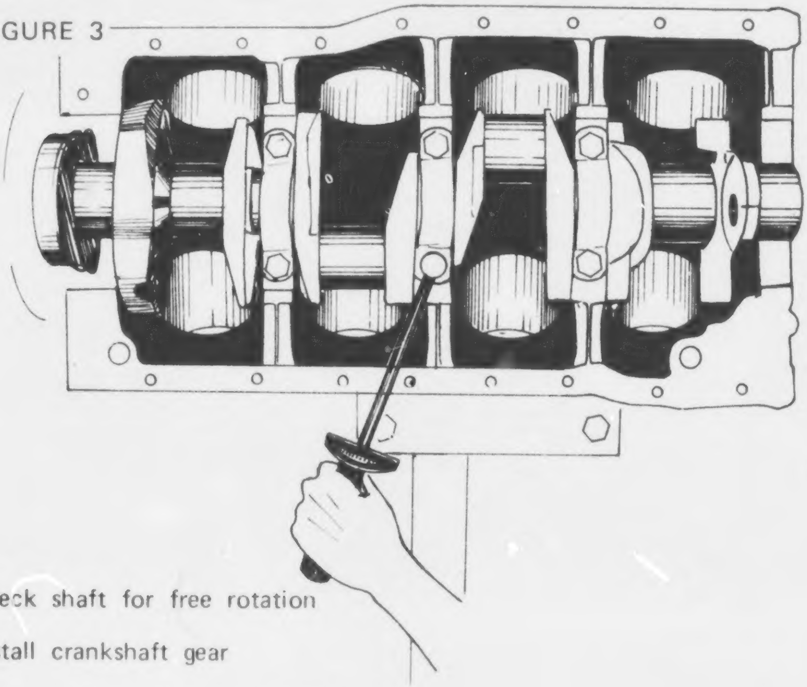
O. Reinstall crankshaft in block

P. Install main bearing caps and bolts

JOB SHEET #2

Q. Torque each bearing cap in a crisscross pattern in steps of one-half, three-fourths, and full torque (Figure 3)

FIGURE 3



R. Check shaft for free rotation

S. Install crankshaft gear

1. Install key in keyway
2. Place gear on crankshaft with timing mark facing away from the block
3. Start the gear partially on the crankshaft key

T. Install timing gear and chain (Figure 4)

1. Rotate the crankshaft so that the timing mark is aligned as specified by manufacturer
2. Place the cam gear on the camshaft and rotate camshaft until the timing mark is aligned as specified by manufacturer
3. Remove cam gear
4. Place timing chain around cam gear and crankshaft gear
5. Align timing marks as cam gear is attached to the camshaft

   (NOTE: The crankshaft gear will have to be driven on as the cam gear is tightened to keep the gears even as they are installed to prevent damage to the timing chain.)

JOB SHEET #2

6. Torque the cam gear retaining bolts

   (NOTE: Make sure all accessory parts are installed with the cam gear, such as the fuel pump cam on some models.)

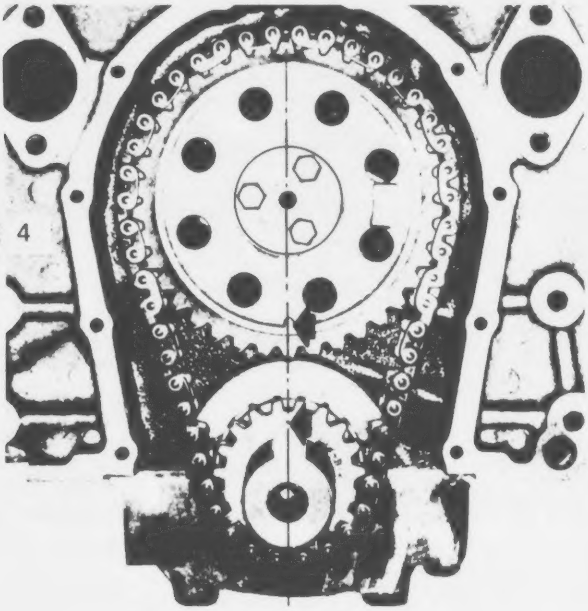


FIGURE 4

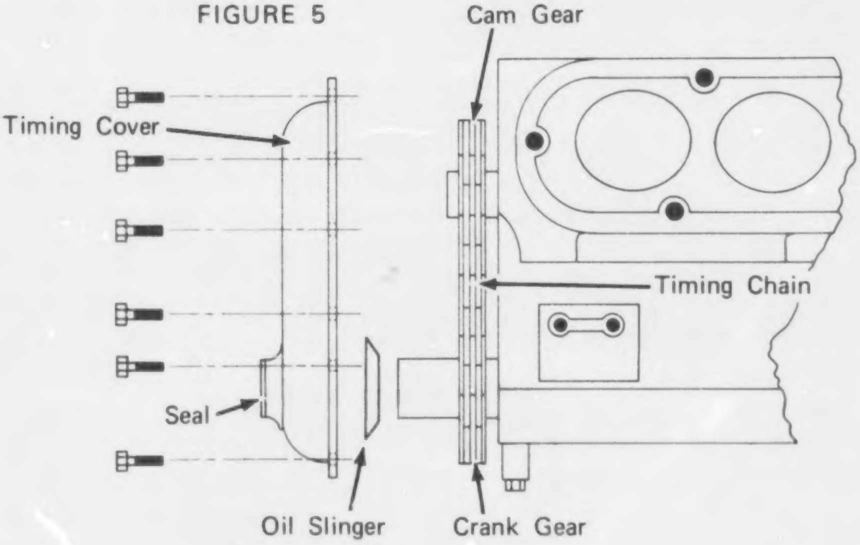
U. Install timing gear cover (Figure 5)

1. Install new seal in timing cover
2. Tap bolt holes flat in cover
3. Apply a thin coat of gasket sealer to cylinder block gasket surface and place gasket on the alignment dowel pins
4. Install the crankshaft oil slinger, if so equipped
5. Install the cover on the cylinder block
6. Start all bolts

JOB SHEET #2

7. Torque bolts

FIGURE 5


Cam Gear
Timing Cover
Timing Chain
Seal
Oil Slinger
Crank Gear

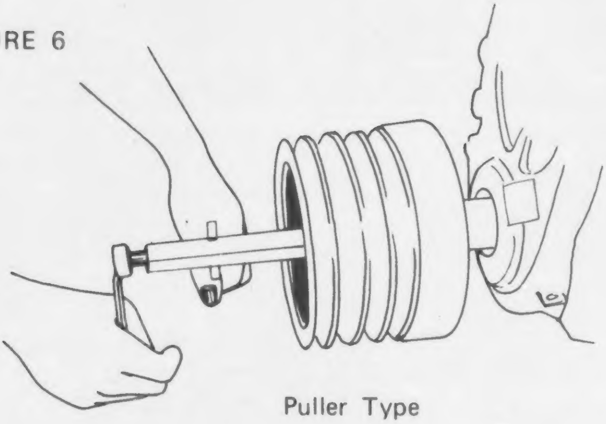
V. Install vibrational damper and drive pulley assembly (Figure 6)

(NOTE: Refer to Figure 6 on the following page.)

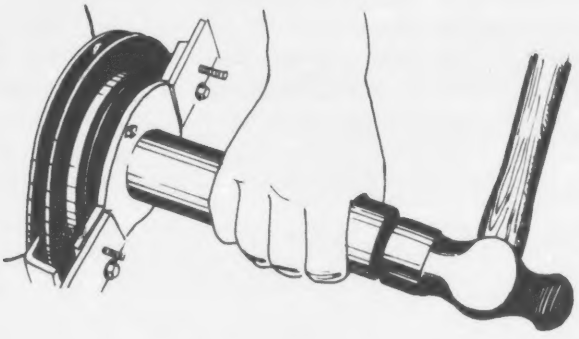
1. Install key in crankshaft keyway if not done previously
2. Lubricate the seal contact area on the drive pulley hub
3. Place the damper and pulley assembly on the crankshaft
4. Align hub keyway with key in crankshaft
5. Force the damper assembly against its seat using the appropriate puller or driver
6. Install and torque retaining bolt if one is used

JOB SHEET #2

FIGURE 6



Puller Type



Driver Type

ENGINE REASSEMBLY
UNIT VII

JOB SHEET #3--INSTALL PISTONS AND CONNECTING ROD ASSEMBLIES

I. Tools and equipment

- A. Basic hand tool set
- B. Safety glasses
- C. Clean shop towels
- D. Piston ring expander
- E. Piston ring compressor
- F. Connecting rod guide set
- G. One-gallon can with open top (3.78 liters)
- H. One quart motor oil, 20 W (0.946 liters)
- I. Lubriplate
- J. Spring gauge and feeler gauges for fitting piston
- K. Torque wrench
- L. Engine repair stand

II. Procedure

(NOTE: This job sheet is designed for assembly purposes only. All repair work and cleaning of components should have already been completed.)

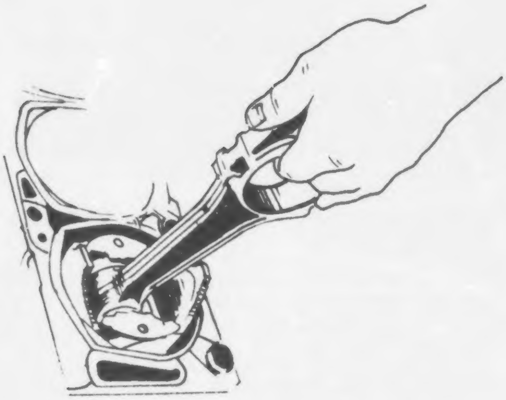
A. Check the fit of piston rings to the cylinder

1. Check ring gap with ring at bottom of ring travel in the cylinder

(NOTE: Start the top compression ring in the cylinder. With the piston upside down, push the ring down the cylinder the length of the piston. See Figure 1 on the following page.)

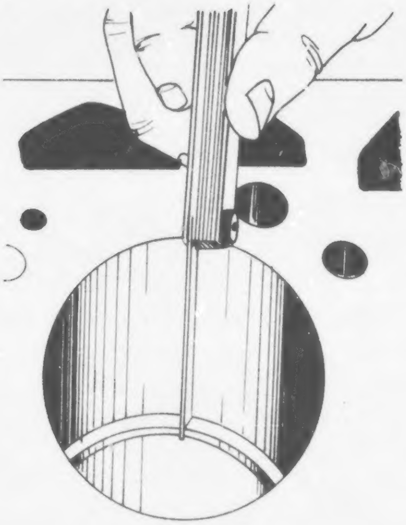
JOB SHEET #3

FIGURE 1



2. Measure the ring gap (Figure 2)

FIGURE 2

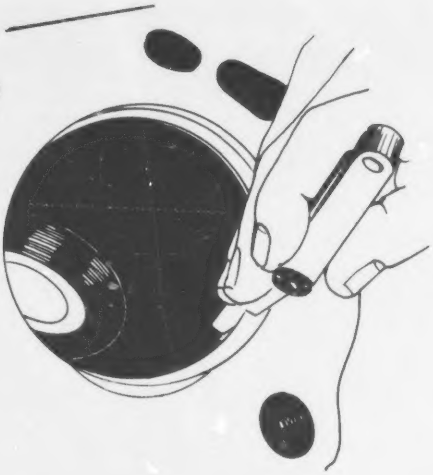


3. Move the ring to the top of the cylinder ring travel

JOB SHEET #3

4. Measure ring gap (Figure 3)

FIGURE 3

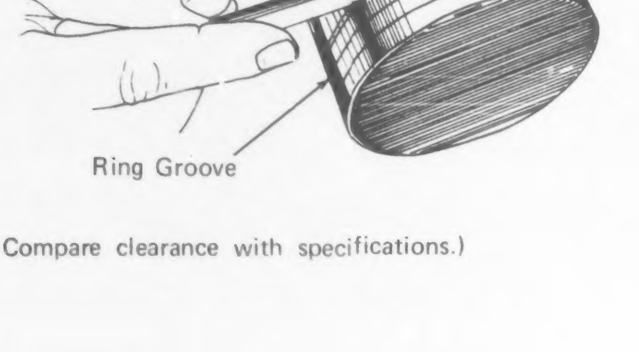


5. Compare these readings with manufacturer's specifications and correct as necessary

   (NOTE: If ring gap is too wide, the cylinder is probably worn excessively or you have the wrong ring set for the engine. If the gap is too narrow, the rings are of the wrong size.)

B. Check fit of compression rings in piston grooves (Figure 4)

FIGURE 4



(NOTE: Compare clearance with specifications.)

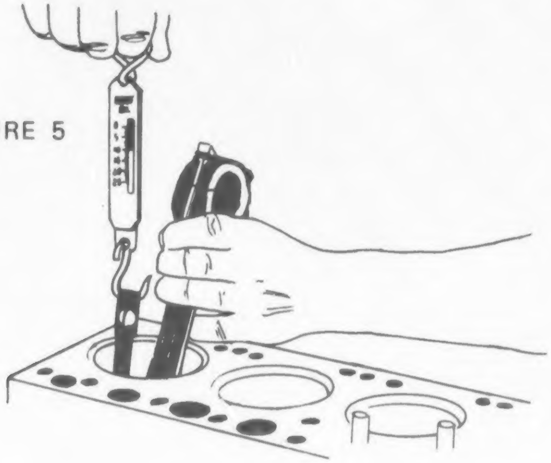
JOB SHEET #3

C. Check piston skirt clearance in cylinder (Figure 5)

1. Invert piston and start in the cylinder
2. Insert feeler gauge on scale between piston skirt and cylinder wall opposite pin boss (Figure 5)
3. Lower piston until the bottom of the piston is just below ring ridge in the top of the cylinder
4. Pull feeler gauge from between piston and cylinder wall while noting the reading on the spring scale

   (NOTE: Compare to manufacturer's specifications for piston skirt clearance.)

FIGURE 5



D. Install ring on piston

1. Secure piston in vise by lightly clamping connecting rod in vise with soft jaws

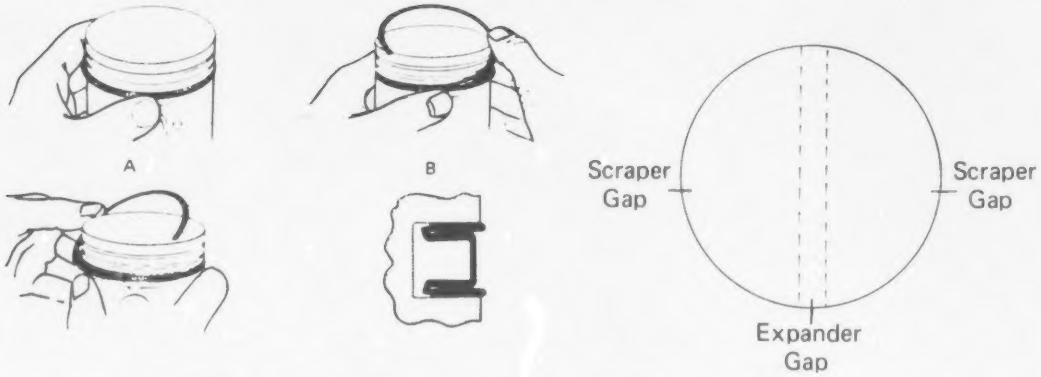
   (CAUTION: Never clamp any part of a piston in a vise for any reason.)

2. Install oil ring in lower groove (Figure 6)
   a. Place expander in groove with ends butted together in correct position
   b. Install oil ring lower scraper with ring gap 90° to either side of expander gap

JOB SHEET #3

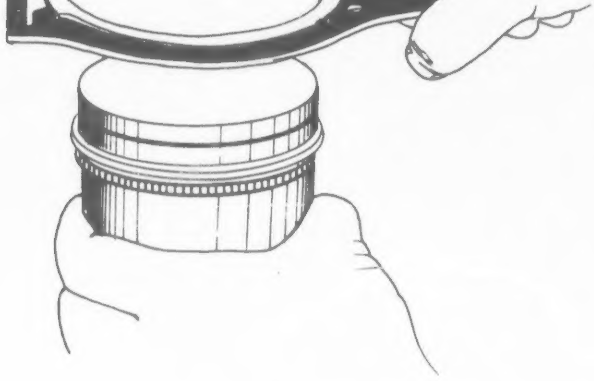
c. Install oil ring upper scraper with ring gap 180° from lower scraper gap

FIGURE 6


A
B
Scraper Gap
Scraper Gap
Expander Gap

3. Install compression rings using ring expander (Figure 7)

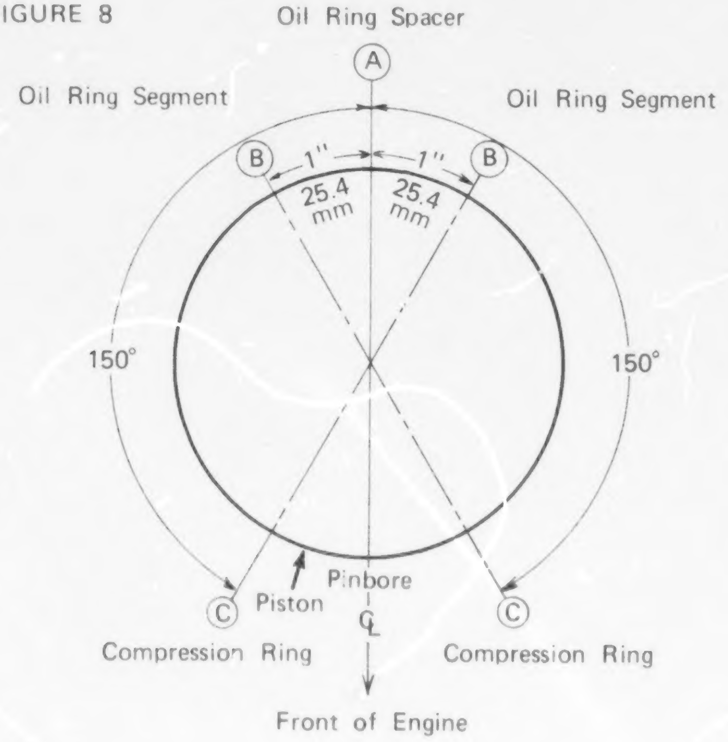
FIGURE 7



JOB SHEET #3

4. Position ring gap on piston (Figure 8)

FIGURE 8


Oil Ring Spacer
A
Oil Ring Segment
Oil Ring Segment
B
B
1"
1"
25.4 mm
25.4 mm
150°
150°
Pinbore
Piston
C
C
℄
Compression Ring
Compression Ring
Front of Engine

E. Install piston in cylinder

(NOTE: Pour a quart [one liter] of oil into the gallon can to provide a method for lubricating the pistons and ring assemblies.)

1. Dip the piston and ring in the can of oil

   (NOTE: Be sure to use a drain pan to catch any oil dripping from piston at the vise and engine.)

2. Place the piston in the vise

3. Open the ring compressor enough to easily fit over the piston rings

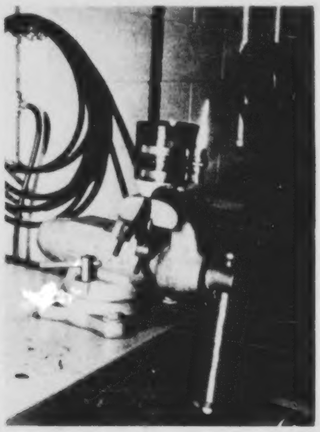
4. Place the ring compressor over the piston and ring assembly with the notches on the edge of the compressor down

JOB SHEET #3

5. Tighten compressor slowly while keeping the compressor straight (Figure 9)

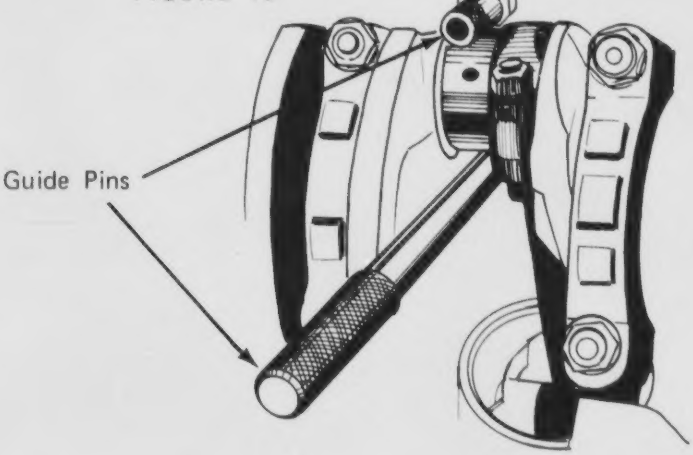
   (NOTE: Tap the compressor very lightly occasionally while tightening to help the rings slip into place. The compressor does not have to be extremely tight.)

FIGURE 9



6. Turn the rod journal for the piston being installed to its outermost position
7. Clean the rod journal
8. Clean and lubricate the cylinder
9. Install guide pin on rod bolts (Figure 10)

FIGURE 10



JOB SHEET #3

10. Insert rod and piston assembly into the cylinder

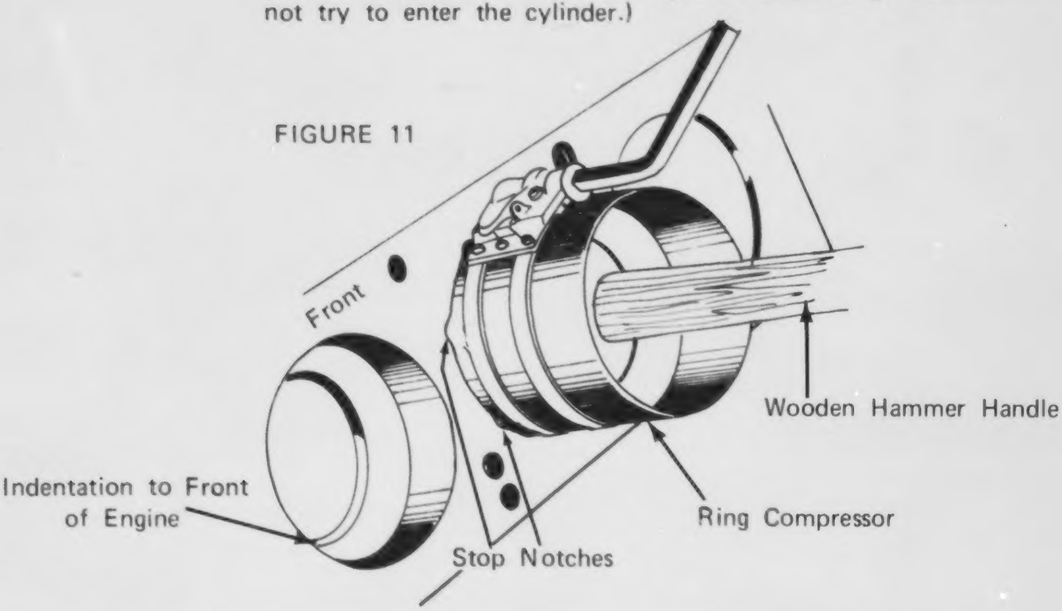
    (NOTE: Be sure the rod and piston assembly is in the same numbered cylinder as the number on the rod.)

11. Rotate piston so that the front marking on the piston is toward the front of the engine

12. Tap the piston into the cylinder gently, using a wooden hammer handle (Figure 11)

    (NOTE: Watch to see that the compressor stays straight and does not try to enter the cylinder.)

FIGURE 11



13. Stop tapping the piston when the top is flush with the cylinder

F. Attach connecting rod to crankshaft journal

1. Clean connecting rod bearing seat

2. Install bearing in rod and rod cap

   (CAUTION: Align the tang on the insert bearing with the groove in the rod bore and be sure it is seated properly.)

3. Pull connecting rod up over the rod journal of the crankshaft

   (CAUTION: Do not bump the journal surface with the rod bolts because the shaft will be damaged.)

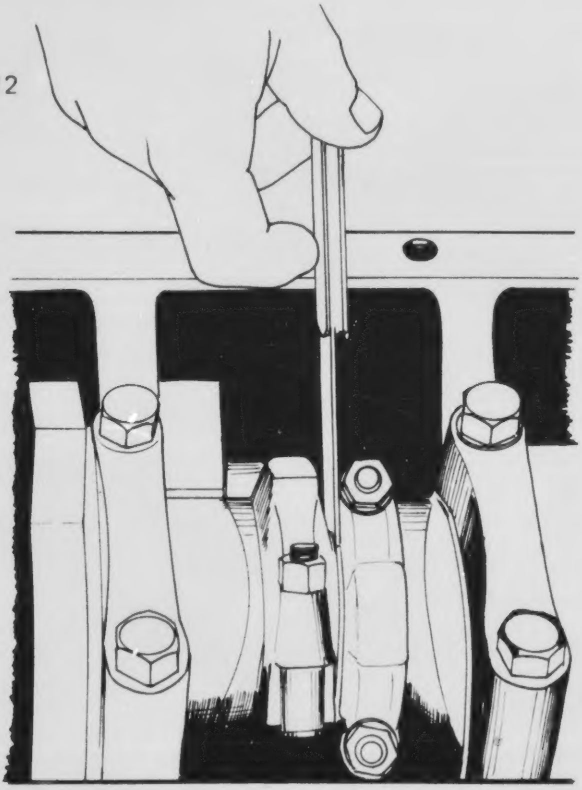
4. Remove the guide pin set from bolts

JOB SHEET #3

5. Measure rod bearing clearance with plastigauge
6. Clean plastigage from bearing and shaft
7. Lubricate rod bearings
8. Install rod cap and torque to specifications
9. Turn crankshaft one complete turn to check for binding or excessive tightness after installing each piston assembly
10. Follow this same procedure for the remaining pistons

G. Check connecting rod side clearance and compare with specifications (Figure 12)

FIGURE 12



ENGINE REASSEMBLY
UNIT VII

JOB SHEET #4--INSTALL OIL PUMP, PICKUP SCREEN, AND OIL PAN

I. Tools and equipment

- A. Basic hand tool set
- B. Safety glasses
- C. Gasket sealer
- D. Lightweight motor oil, 20 W
- E. Torque wrench
- F. Silicone sealer
- G. Engine repair stand

II. Procedure

(NOTE: Rotate the engine on the engine repair stand so the crankcase is facing up.)

- A. Set the oil pump in the can of oil used to soak the pistons
- B. Rotate the pump drive shaft so that oil will be pulled through the pump
- C. Install the oil pump

  (NOTE: On some models the pickup screen will have to be pressed on the pump before the pump is installed. Others can be bolted on after pump installation.)

  1. Place the drive shaft on the pump, if so equipped
  2. Place pump on engine and start retaining bolts
  3. Torque retaining bolts
  4. Install pickup screen if not already installed

     (NOTE: The screen should be properly aligned to fit close to the bottom of the pan.)

JOB SHEET #4

D. Install any special oil baffels or other special components

E. Install oil pan

   1. Apply a light coat of sealer to the block at the pan gasket mating surface

   2. Lay the gasket on the block while making sure that all the ends are properly seated

   3. Apply extra sealer at all gasket seams

   4. Tap the pan bolt holes flat using the edge of the workbench

   5. Position the oil pan onto the gasket

   6. Install all pan bolts before tightening any more than necessary

   7. Tighten all bolts to a very light pressure

   8. Torque all bolts

      (CAUTION: Do not overtighten the bolts because this will mash the gasket apart.)

   9. Tighten oil pan drain plug

ENGINE REASSEMBLY
UNIT VII

JOB SHEET #5--INSTALL CYLINDER HEAD, INTAKE MANIFOLD, AND EXHAUST MANIFOLD

I. Tools and equipment

- A. Basic hand tool set
- B. Safety glasses
- C. Shop towels
- D. Gasket sealer
- E. Torque wrench
- F. Removable cylinder head guide dowels
- G. Silicone cement
- H. Engine repair stand

II. Procedure

(NOTE: Rotate the engine on engine repair stand to its normal upright position.)

A. Install valve lifters

1. Clean the lifter bores in the block
2. Lubricate the outside of the lifter
3. Place the lifters in their respective bores

   (NOTE: If the camshaft and lifters are the same as removed, the lifters should be placed back in their original positions.)

4. install lifter chamber cover on six-cylinder models

B. Install any baffels or vapor separators as necessary in the lifter valley

C. Install cylinder heads

1. Clean cylinder block head gasket surface
2. Install removable dowels if there are no dowel pins on the block to align the gasket and head
3. Apply appropriate gasket sealer to head gasket

JOB SHEET #5

4. Place head gasket on cylinder block

5. Clean cylinder head gasket mating surface

6. Place the cylinder head carefully on the block

7. Place the head bolts in their proper locations according to length

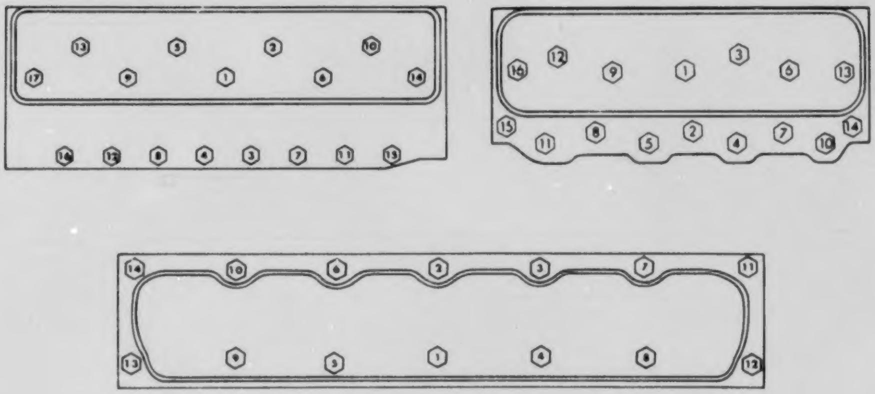
   (NOTE: Head bolts that screw into the water jacket must have a nonhardening sealer on the threads to prevent coolant seepage.)

8. Tighten head bolts until they just touch the head

9. Torque the head bolts to one-half the specified torque in a sequence recommended by the manufacturer

10. Retorque the head bolts to three-fourths the specified torque in sequence (Figure 1)

FIGURE 1



11. Retorque the head bolts to full specified torque in sequence

12. Follow this procedure for installing the other head on V-engine

D. Install valve rocker arms and push rods

   1. Place the push rods through the guides in the cylinder head into the lifter recess

      (NOTE: Be sure the push rods are in the proper hole and have the correct end up.)

JOB SHEET #5

2. Place the rocker arms on the head

3. Align the push rods with the rocker arms as the rocker arm bolts are tightened

4. Torque rocker arm stand retaining bolts

   (CAUTION: On models where the rocker arm pivots on a stud, tighten only until the slack is taken out of the rocker arm to prevent damage to the valve train.)

   (NOTE: Follow valve adjustment procedures outlined by the manufacturer for this vehicle.)

E. Install intake manifold (V-8 model)

(NOTE: On most six-cylinder engines the exhaust and intake manifold will be installed as one component.)

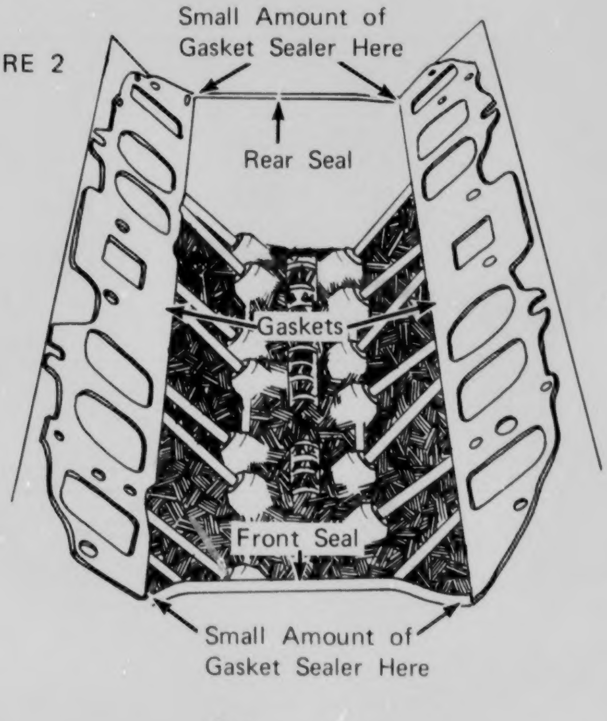
1. Wipe clean the intake manifold gasket surfaces on the manifold and the engine

2. Install the end rail gaskets on V-engines (Figure 2)

3. Install side gaskets on V-engines or intake gasket on in-line type engines

4. Place a small amount of gasket sealer in each corner where the gaskets overlap each other (Figure 2)

FIGURE 2


Small Amount of Gasket Sealer Here
Rear Seal
Gaskets
Front Seal
Small Amount of Gasket Sealer Here

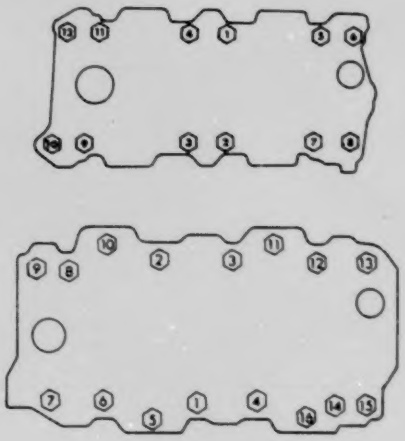
JOB SHEET #5

5. Set the intake manifold carefully in place on the engine

6. Install all manifold bolts

7. Torque the bolts in sequence (Figure 3)

FIGURE 3



Torque Sequence for Two Basic V-8 Manifolds

(NOTE: Some of the manifold bolts will probably have to be removed later to attach accessories.)

F. Install exhaust manifolds

(NOTE: Most six-cylinder exhaust manifolds are either a part of the cylinder head or are installed as a component part of the intake manifold.)

1. Wipe clean the cylinder head gasket surface and the exhaust manifold gasket surface

2. Attach manifolds with gasket to cylinder head

   (NOTE: Some models do not require an exhaust manifold gasket. Do not use gasket sealer on exhaust gaskets.)

3. Torque manifold attaching bolts in sequence

JOB SHEET #5

G. Adjust valves

(NOTE: The lifters must be on the heel of the cam lobe to obtain correct valve adjustment. To accomplish this, the engine crankshaft should be turned to place the No. 1 piston in firing position. At this position one-half of the valves can be adjusted. Rotate the crankshaft one complete turn and other half of the valves can be adjusted. Use the following steps as a guide.)

1. Locate No. 1 cylinder in firing order

2. Rotate engine crankshaft in direction of normal operation and watch for the alignment of the timing mark on the crankshaft pulley with the "0" mark on the timing cover and the movement of the No. 1 cylinder valves

   (NOTE: If valves ARE NOT moving as the timing marks align, the valves can be adjusted. If the valves ARE moving as the timing marks align, rotate one complete turn before valves can be adjusted.)

3. Make adjustment for hydraulic lifter valves (Figure 4)

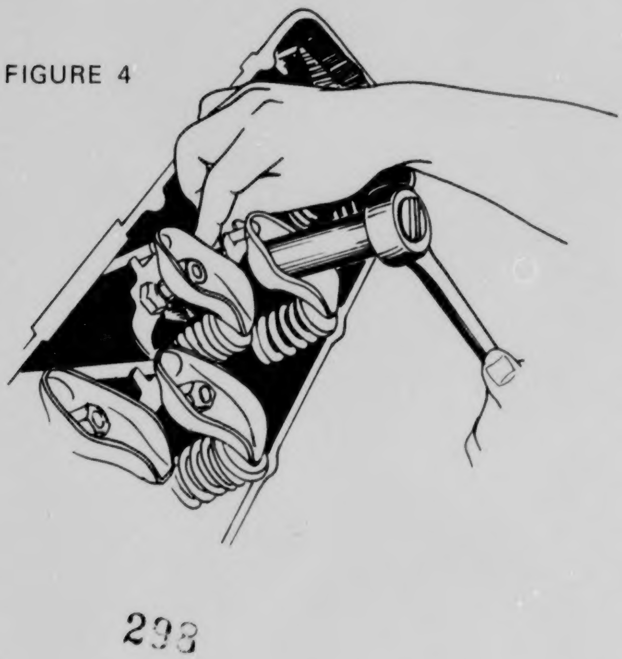
   a. Back off adjusting nut until lash is felt at the push rod

      (NOTE: This can be determined by checking push rod side play while turning adjusting nut.)

   b. Tighten adjusting nut back until "0" clearance between push rod and rocker arm is obtained

   c. Tighten adjusting nut the additional number of turns recommended by the manufacturer

FIGURE 4



JOB SHEET #5

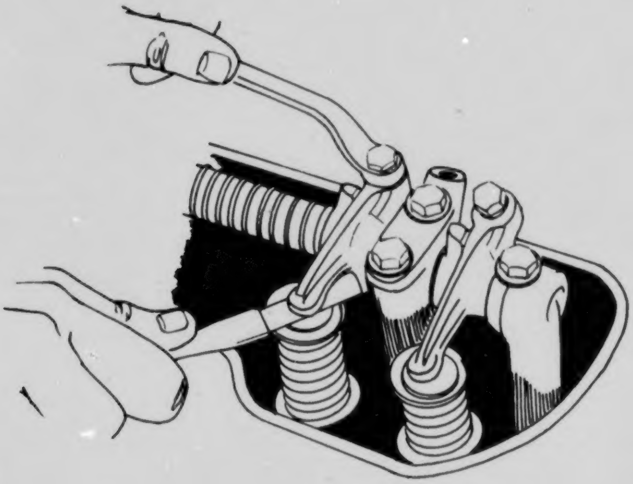
4. Make adjustment for solid lifter valves (Figure 5)

    a. Place correct thickness feeler gauge between rocker arm and valve stem

    b. Tighten adjuster until a slight drag is felt while moving the feeler gauge

    c. Tighten locknut if so equipped

FIGURE 5



ENGINE REASSEMBLY
UNIT VII

JOB SHEET #6--INSTALL ENGINE ACCESSORY COMPONENTS

I. Tools and equipment

- A. Basic hand tool set
- B. Safety glasses
- C. Clean shop towels
- D. Torque wrench
- E. Gasket sealer

II. Procedure

(NOTE: This job sheet is a sequence of installing engine accessory components and will cover only the generally used components.)

A. Install the fuel pump

1. Clean gasket surfaces
2. Apply sealer to the fuel pump gasket surface
3. Place the gasket on the pump
4. Install the attaching bolts through the pump and gasket holes
5. Install the fuel pump push rod if so equipped

   (NOTE: On models with push rods, tighten the pump bolts very evenly to avoid the pump lever binding on the push rod and bending it.)

6. Install pump and torque bolts

B. Install the water pump

(NOTE: Other accessories such as the power steering pump and air compressor are connected by water pump attaching bolts also.)

1. Clean gasket surface
2. Apply gasket sealer to both the pump and engine gasket surface

JOB SHEET #6

3. Place the gasket on the pump

4. Start at least two bolts through the pump and gasket

5. Install the pump

6. Torque the pump attaching bolts

   (NOTE: Do not install the fan until engine is installed because the fan is easily bent.)

C. Install front motor mount

D. Install the ignition distributor

1. Crank the engine in operating rotation to position No. 1 cylinder on top dead center compression stroke

   (NOTE: When the timing marks align on the vibration damper and the timing stationary mark, the engine is either on TDC compression stroke or TDC exhaust stroke. It must be on TDC compression. To determine this, both valves are closed on TDC compression stroke.)

2. Install the distributor with the case and rotor positioned as indicated in the ignition section of the service manual

   (NOTE: If the distributor does not go all the way in, the oil pump drive shaft has not aligned with the bottom of the distributor. Therefore, the engine must be turned until they align and it drops into place.)

3. Install distributor hold-down bracket and bolt and tighten lightly

E. Install ignition coil

F. Connect distributor primary lead to the negative terminal of the coil

G. Install any other accessories that were on the engine when it was removed

ENGINE REASSEMBLY
UNIT VII

TEST

NAME ______________________________ SCORE ____________________

1. Match the terms on the right to the correct definitions.

_____a. Tightening pattern that draws two components together evenly at all points

_____b. Variation of the fit or adjustment of two related working parts

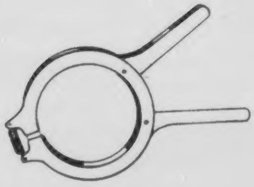
_____c. Lithium-based lubricant with high impact and temperature stability qualities

_____d. Flat strip, usually of cork or metal or both, placed between two machined surfaces to provide a tight seal

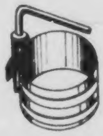
_____e. Position of piston at its highest travel in the cylinder

1. TDC (top dead center)
2. Lubriplate
3. Torque sequence
4. Tolerance
5. Gasket

2. Identify the tools below and on the following page by writing the correct names in the blanks provided.



a. ______________



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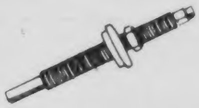
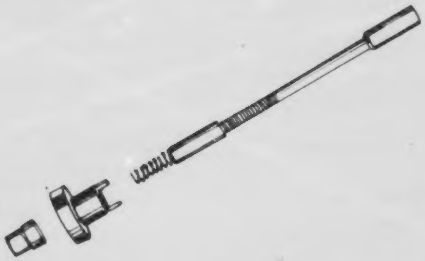
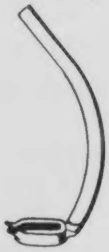


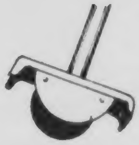
c. ______________



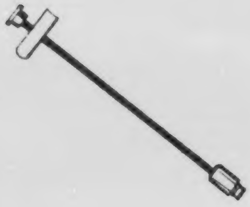
d. ______________

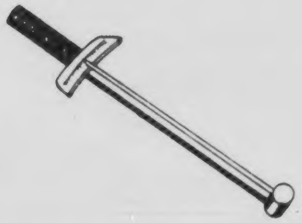


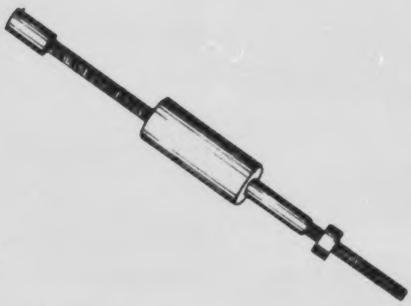
e. ______________



f. ______________







g. ______________ h. ______________ i. ______________

3. List five reasons for torqueing bolts to specifications in an engine.

a. ____

b. ____

c. ____

d. ____

e. ____

4. Demonstrate the ability to:

a. Install camshaft and bearings.

b. Install crankshaft, bearings, timing gears, and timing cover.

c. Install pistons and connecting rod assemblies.

d. Install oil pump, pickup screen, and oil pan.

e. Install cylinder head, intake manifold, and exhaust manifold.

f. Install engine accessory components.

(NOTE: If the above activities have not been accomplished prior to the test, ask the instructor when they should be completed.)

ENGINE REASSEMBLY
UNIT VII

ANSWERS TO TEST

1. a. 3
   b. 4
   c. 2
   d. 5
   e. 1
2. a. Ring expander
   b. Ring compressor
   c. Vibration damper tool
   d. Piston pin press
   e. Push rod installing tool
   f. Rear main bearing seal tool
   g. Valve lifter installing tool
   h. Torque wrench
   i. Camshaft bearing remover and installer
3. a. To prevent overtightening and stretching of bolts
   b. To prevent distortion of the mating surfaces between the parts
   c. To prevent thread damage
   d. To prevent leaks from uneven mating surfaces
   e. To prevent cylinder wall distortion from overtightened head bolts
4. Performance skills evaluated to the satisfaction of the instructor

ENGINE INSTALLATION
UNIT VIII

UNIT OBJECTIVE

After completion of this unit, the student should be able to install a completely assembled engine and make all connections and adjustments necessary to the vehicle for delivery to the customer. This knowledge will be evidenced through demonstration and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with engine installation to the correct definitions.
2. List safety precautions to observe during engine installation.
3. List factors to consider when installing an engine.
4. List items to check or adjust before starting a new or rebuilt engine.
5. Discuss in a short paragraph break-in procedure for an engine.
6. Demonstrate the ability to:
    a. Install engine with automatic transmission.
    b. Install engine with standard transmission.
    c. Adjust and start newly installed engine.

ENGINE INSTALLATION
UNIT VIII

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Secure material and equipment for job sheet demonstrations.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss procedures outlined on the job sheets.

   G. Give test.

   H. Evaluate student performance of job sheets.

II. Unit references:

   A. Ellinger, Herbert E. *Automechanics.* Englewood Cliffs, New Jersey: Prentice-Hall Inc., 1975.

   B. Crouse, William H. *Automotive Engine Design.* New York: McGraw-Hill Book Co., 1970.

   C. *Chevrolet Service Manual.* Detroit: Chevrolet Motor Div./General Motors Corp., 1977.

   D. Crouse, William H. *Automotive Mechanics.* 7th ed. New York: McGraw-Hill Book Co., 1975.

   E. *Chrysler, Plymouth, Dodge Chassis Service Manual.* Detroit: Chrysler Corp., 1976.

   F. *Ford Service Manual.* Dearborn, Michigan: Ford Motor Co., 1975-76.

ENGINE INSTALLATION
UNIT VIII

INFORMATION SHEET

I. Terms and definitions

   A. Engine break-in--Procedure to effectively help frictional parts in a new or rebuilt engine adjust to each other

   B. Lug an engine--To load an engine so heavily that under acceleration it does not gain speed

   C. Road test--Systematic method of driving a vehicle under varied conditions to determine its general condition

II. Safety precautions to observe during engine installation

   A. Do not spill gasoline around engine

   B. Do not cause an electrical arc around the battery

   C. Do not lift heavy weights around the engine without assistance

   D. Keep clear of the engine while it is on the hoist

   E. Do not work under the vehicle while the engine is on the hoist

III. Factors to consider when installing an engine

   A. Have ample work area for equipment and vehicle

   B. Have a precise plan of action

   C. Obtain proper tools and equipment

   D. Have all specifications for adjustments

   E. Know your job

IV. Items to check and adjust before starting a new or rebuilt engine

   A. Check coolant level

   B. Check oil level

   C. Adjust valves

   D. Adjust ignition point dwell

   E. Adjust ignition timing

   F. Adjust engine idle

INFORMATION SHEET

V. Break-in procedure for an engine

   A. Make engine tune-up adjustments to correct settings

   B. Check all fluid levels

   C. Check the engine and its accessories for oil, coolant, or fuel leaks

   D. Road test the vehicle

      1. Bring the engine to operating temperature

      2. Obtain a speed of approximately 25-30 mph (40-50 km/h)

      3. Accelerate vehicle at full throttle until a speed of 40-45 mph (65-72 km/h); then ease up and let the engine smooth out at 50 mph (80 km/h) for at least two miles (3.219 km)

         (CAUTION: When accelerating, do not let automatic transmission shift into passing gear and do not lug a standard transmission vehicle. Never let engine overheat.)

      4. Repeat this road test procedure approximately ten times

ENGINE INSTALLATION
UNIT VIII

JOB SHEET #1--INSTALL ENGINE WITH AUTOMATIC TRANSMISSION

I. Tools and equipment

  A. Engine hoist

  B. Engine lift adapter

  C. Transmission support

  D. Jack stands

  E. Floor jack

  F. Basic hand tool set

  G. Safety glasses

  H. Creepers

  I. Fender covers

II. Procedure

  A. Attach lift adapter to engine

  B. Connect hoist to engine adapter

  C. Lift engine enough to take the load off the engine repair stand

  D. Remove engine repair stand

  E. Install torque converter drive plate

  F. Place fender covers on fenders

  G. Check torque converter to see that it is engaged in the front pump

  H. Raise engine high enough to clear vehicle

  I. Position the engine squarely over the engine compartment of the vehicle

  J. Lower the engine into the vehicle slowly while watching for any binds

  K. Align engine with the transmission attaching surface

JOB SHEET #1

L. Move the engine towards the transmission

M. Align the marks on the drive plate and torque converter

(NOTE: The transmission may have to be raised or lowered with the floor jack to align with the engine. Do not force the engine into position. As the engine and transmission come into alignment, they will slide together.)

N. Start both bottom bolts to hold the engine and transmission together

O. Lower the engine while aligning the motor supports

P. Bolt the motor supports into place

Q. Remove the hoist

R. Raise the vehicle and secure on jack stands

S. Install the remainder of the engine-to-transmission bolts and torque

T. Remove transmission support

U. Install the bolts or nuts that connect the drive plate to the torque converter

V. Torque the bolts once they are all installed

W. Install torque converter inspection cover

X. Install starter

Y. Connect the exhaust pipes to manifold, using new gaskets as necessary

Z. Reconnect any other items disconnected during engine removal

AA. Lower vehicle to the floor

BB. Install fan assembly

CC. Install all drive belts

DD. Install radiator and shroud

  1. Place shroud over fan

  2. Install radiator in yoke

JOB SHEET #1

3. Connect transmission cooling lines

   (CAUTION: Use tubing wrench to back-up the cooling line connection to prevent damage to radiator or line.)

4. Connect lower and upper radiator hoses

5. Connect radiator shroud to radiator

EE. Connect heater hoses

FF. Connect electrical wiring

1. Connect alternator wiring
2. Connect air conditioner compressor clutch
3. Connect temperature gauge sending unit
4. Connect oil pressure gauge sending unit
5. Connect ignition coil primary lead
6. Connect emission control components
7. Connect engine ground wires to body
8. Connect other electrical items disconnected during engine removal

GG. Install distributor cap and secondary wires

HH. Install the carburetor

1. Remove carburetor type lift adapter, if used
2. Place new gasket on manifold
3. Attach carburetor to manifold
4. Connect accelerator linkage and springs
5. Connect transmission throttle linkage, if so equipped
6. Connect automatic choke
7. Connect accessory hoses for heater and air conditioner, power brakes, cruise control, and transmission modulator valve

8. Connect fuel line from pump to carburetor

   (CAUTION Be sure to use tubing wrench to back-up the fitting while tightening the line.)

   (NOTE: Replace fuel filter.)

II. Connect fuel line from fuel tank to fuel pump

JJ. Connect any other accessories necessary to complete installation of engine

KK. Install the hood

LL. Install the battery

(CAUTION: Connect the ground or negative cable last to prevent a possible electrical arc.)

(NOTE: Proceed to Job Sheet #3 for adjusting and starting the engine.)

ENGINE INSTALLATION
UNIT VIII

JOB SHEET #2--INSTALL ENGINE WITH STANDARD TRANSMISSION

I. Tools and equipment

  A. Engine hoist

  B. Engine lift adapter

  C. Engine support (frame type)

  D. Jack stands

  E. Floor jack

  F. Basic hand tool set

  G. Safety glasses

  H. Creeper

  I. Fender covers

  J. Clutch alignment tool

II. Procedure

  A. Attach engine lift adapter to engine

  B. Connect hoist to engine lift adapter

  C. Lift engine enough to take the load off the engine repair stand

  D. Disconnect the engine repair stand

  E. Lower engine to floor and secure in upright position with enough clearance for flywheel installation

  F. Install flywheel

  G. Torque bolts

  H. Install clutch and pressure plate using alignment tool

  I. Torque bolts and remove alignment tool

  J. Install clutch housing

  (NOTE: Some models have the clutch housing as a part of the transmission housing, so it will be installed with the transmission.)

JOB SHEET #2

K. Place fender covers on fenders

L. Raise engine high enough to clear the radiator yoke

M. Position the engine over the center of the engine compartment of the vehicle

N. Lower the engine into the vehicle slowly while watching for any binds

O. Align the motor supports

P. Attach the motor supports

Q. Raise the vehicle with the floor jack while keeping the engine weight mainly on the hoist

R. Secure the vehicle on jack stands

S. Support the engine from below with an engine support or jack

T. Remove the engine hoist

U. Install the clutch release bearing

V. Stab the transmission into the clutch

W. Secure the transmission with the attaching bolts

X. Install crossmember

Y. Connect rear motor support to crossmember

Z. Install driveshaft, being sure to align reference marks

AA. Connect transmission shift linkage

BB. Connect speedometer cable

CC. Connect backup light wires to switch

DD. Install clutch inspection cover

EE. Connect clutch linkage

FF. Adjust clutch to 1 inch (2.54 cm) pedal free travel

GG. Install starter

HH. Install exhaust pipe to manifold using gaskets as necessary

II. Connect any other items disconnected during engine removal

JJ. Lower vehicle to the floor

JOB SHEET #2

KK. Install radiator

1. Install fan assembly
2. Install all drive belts
3. Place fan shroud over fan
4. Install radiator on radiator yoke
5. Attach shroud to radiator
6. Connect radiator hoses

LL. Connect heater hoses

MM. Connect electrical wiring

1. Connect alternator wiring
2. Connect air conditioner compressor clutch
3. Connect temperature gauge sending unit
4. Connect oil pressure gauge sending unit
5. Connect ignition coil primary lead
6. Connect emission control components
7. Connect engine ground wires to body
8. Connect other electrical items disconnected during engine removal

NN. Install distributor cap and secondary wires

OO. Install the carburetor

1. Remove carburetor type lift adapter, if used
2. Place new gasket on manifold
3. Attach carburetor to manifold
4. Connect accelerator linkage and springs
5. Connect automatic choke
6. Connect fuel line from fuel pump to carburetor

   (CAUTION: Be sure to use a tubing wrench to back up the connection while tightening the line.)

   (NOTE: Replace fuel filter, as necessary.)

JOB SHEET #2

PP. Connect power brakes, accessory hoses for heater and air conditioner, cruise control, and emission control components

QQ. Connect fuel line from tank to fuel pump

RR. Install hood

SS. Install battery

(CAUTION: Connect the ground or negative cable last to prevent a possible electrical arc.)

(NOTE: Proceed to Job Sheet #3 for adjusting and starting the engine.)

ENGINE INSTALLATION
UNIT VIII

JOB SHEET #3--ADJUST AND START NEWLY INSTALLED ENGINE

I. Tools and equipment

  A. Basic hand tool set

  B. Safety glasses

  C. Timing light

  D. Tack-dwell tester

  E. Feeler gauge set

  F. Clean shop towels

  G. Fender covers

  H. Gasket sealer

  I. Spark plug gauge

II. Procedure

  A. Install new oil filter

  B. Fill the crankcase with the specified amount of 20 W motor oil

  C. Close coolant system drain plugs

  D. Fill cooling system with coolant

  (NOTE: Leave the radiator cap loose so that the coolant level may be checked easily after the engine has run for a short time.)

  E. Crank the engine for approximately twenty seconds

  F. Install spark plugs

  G. Check dwell and timing

    1. Connect tack-dwell tester

    2. Connect timing light

JOB SHEET #3

3. Turn the tester to Dwell and to correct number of cylinders
4. Crank engine and take dwell reading
5. Adjust dwell to proper setting
6. Crank engine and check timing
7. Adjust timing roughly to specification
8. Start engine

   (NOTE: Have instructor present before starting engine.)
9. Check oil pressure as soon as the engine starts to see that it comes up to at least minimum specified by manufacturer
10. Recheck dwell reading and adjust as necessary
11. Set timing to specifications
12. Switch tack-dwell tester to the Tack positon
13. Adjust engine curb idle to approximately 1500 rpm

H. Check for any coolant or oil leaks and repair as necessary

I. Prepare vehicle for road test with the instructor

J. Perform break-in procedure on road test

K. Readjust dwell, timing, and engine idle after road test

ENGINE INSTALLATION
UNIT VIII

TEST

NAME ____________________ SCORE __________

1. Match the terms on the right to the correct definitions.

______a. Procedure to effectively help frictional parts in a new or rebuilt engine adjust to each other

______b. To load an engine so heavily that under acceleration it does not gain speed

______c. Systematic method of driving a vehicle under varied conditions to determine its general condition

1. Road test
2. Engine break-in
3. Lug an engine

2. List five safety precautions to observe during engine installation.

a. ______________________________
b. ______________________________
c. ______________________________
d. ______________________________
e. ______________________________

3. List four factors to consider when installing an engine.

a. ______________________________
b. ______________________________
c. ______________________________
d. ______________________________

4. List items to check or adjust before starting a new or rebuilt engine.

a. ______________________________
b. ______________________________
c. ______________________________
d. ______________________________
e. ______________________________
f. ______________________________

5. Discuss break-in procedure for an engine.

____

____

____

____

____

6. Demonstrate the ability to:

   a. Install engine with automatic transmission.

   b. Install engine with standard transmission.

   c. Adjust and start newly installed engine.

   (NOTE: If the above activities have not been accomplished prior to the test, ask the instructor when they should be completed.)

ENGINE INSTALLATION
UNIT VIII

ANSWERS TO TEST

1. a. 2
   b. 3
   c. 1
2. a. Do not spill gasoline around engine
   b. Do not cause an electrical arc around the battery
   c. Do not lift heavy weights around the engine without assistance
   d. Keep clear of the engine while it is on the hoist
   e. Do not work under the vehicle while the engine is on the hoist
3. Any four of the following:
   a. Have ample work area for equipment and vehicle
   b. Have a precise plan of action
   c. Obtain proper tools and equipment
   d. Have all specifications for adjustments
   e. Know your job
4. a. Check coolant level
   b. Check oil level
   c. Adjust valves
   d. Adjust ignition point dwell
   e. Adjust ignition timing
   f. Adjust engine idle
5. Discussion should include:
   a. Make engine tune-up adjustments to correct settings
   b. Check all fluid levels

c. Check the engine and its accessories for oil, coolant, or fuel leaks

d. Road test the vehicle

1) Bring engine to operating temperature

2) Obtain a speed approximately 25-30 mph (40-50 km/h)

3) Accelerate vehicle at full throttle until a speed of 40-45 mph (65-72 km/h); then ease up and let the engine smooth out at 50 mph (80 km/h) for at least two miles (3.219 km)

4) Repeat this road test procedure approximately ten times

6. Performance skills evaluated to the satisfaction of the instructor

BASIC ELECTRICAL THEORY
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify types of electrical circuits, basic electrical symbols, and testing instruments. The student should be able to discuss factors concerning electrical flow, voltage, amperage, and ohms and characteristics of magnetism and electromagnetism. The student should be able to demonstrate the ability to construct series and parallel circuits. This knowledge will be evidenced through demonstration and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with basic electrical theory to the correct definitions.
2. Match the parts of an atom to the correct electrical values.
3. Describe electricity according to the electron theory.
4. State the basic factors of electrical flow in a circuit.
5. Discuss the relationship of voltage, amperage, and ohms to current flow.
6. State Ohm's law.
7. Calculate problems dealing with Ohm's law.
8. List factors which affect resistance in a conductor.
9. Identify basic electrical symbols.
10. List the components of a basic electrical circuit.
11. Identify types of electrical circuits.
12. Identify instruments used for testing electrical circuits.
13. Match the test instruments with the correct method of connecting them.
14. Match the basic electrical circuit failures to the correct causes.
15. Select from a list the characteristics of magnetism.

16. Select from a list the characteristics of electromagnetism.
17. Describe electromagnetic induction.
18. List factors which determine magnitude of induced voltage.
19 Demonstrate the ability to.
    a. Construct a series circuit.
    b. Construct a parallel circuit.

BASIC ELECTRICAL THEORY
UNIT I

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information, assignment, and job sheets.

   C. Make transparencies.

   D. Secure materials needed for demonstrations.

   E. Discuss unit and specific objectives.

   F. Discuss information and assignment sheets.

   G. Evaluate assignment sheets.

   H. Demonstrate and discuss procedures outlined on the job sheets.

   I. Give test.

II. Unit references:

   A. *Electrical Systems.* Fundamentals of Service Series. Moline, Illinois: Deere and Co., 1972.

   B. Billiet, Walter E., and Goings, Leslie F. *Automotive Electrical Systems.* 3rd ed. Chicago: American Technical Society, 1970.

   C. Crouse, William H. *Automotive Mechanics*. 7th ed. New York: Webster Div./McGraw-Hill Book Co., 1975.

   D. *Chevrolet Chassis Overhaul Manual.* Detroit, Michigan: Chevrolet Motor Div./General Motors Corp., 1974.

   E. *Chrysler, Plymouth, Dodge Electrical Service Manual*. Detroit: Chrysler Corp., 1976.

   F. Crouse, William H. *Automotive Electrical Equipment.* 8th ed. New York: McGraw-Hill Book Co., 1976.

   G. *Ford Electrical Car Shop Manual*. Dearborn, Michigan: Ford Motor Co., 1975-76.

BASIC ELECTRICAL THEORY
UNIT I

INFORMATION SHEET

I. Terms and definitions

  A. Atom--Smallest particle into which an element can be divided

  B. Proton--Positively charged particle in the nucleus of an atom

  C. Electron--Negatively charged particle that circles the nucleus of an atom

  D. Positively charged atom--Atom with too few electrons

  E. Negatively charged atom--Atom with too many electrons

  F. Ion--Atom or group of atoms that carries a positive or negative electrical charge as a result of having lost or gained electrons

  G. Conductor--Any material which allows electrical current to flow through easily

  H. Insulator--Material that resists the flow of electrical current

  I. Current--Flow of electrons measured in amperes

  J. Electromotive force (EMF)--Force which tends to cause a flow of electricity which is measured in volts

  K. Load (consumer)--Object that converts electrical energy into heat, light, or mechanical energy

  L. Circuit--Continuous path along a conductor through which electrical current can flow from a source, through a load, and back to the source

  M. Direct current (D.C.)--Steady flow of electrons moving continually in the same direction along a conductor from a point of high potential to one of lower potential

  N. Alternating current (A.C.)--Flow of electrons which reverses its direction of flow at intervals in a conductor

  O. Polarity--Collective term applied to the positive and negative ends of a magnet or the direction of current flow in a circuit

  P. Magnet--Material which has the property of attracting iron or other magnets

INFORMATION SHEET

Q. Magnetic field--That area near a magnet in which its property of magnetism can be detected

R. Flux lines--Alternate name for the magnetic lines of force existing in the space around a permanent magnet or electromagnet

II. Parts of an atom and their values (Transparency 1)

A. Proton--Positive charge

B. Electron--Negative charge

(NOTE: Each atom has an equal number of electrons and protons.)

III. Electricity according to electron theory (Transparency 1)

A. Electrons move through a conductor from negative to positive

B. Some type of force (voltage) is needed to cause the free electrons to move from atom to atom

C. Complete circuit is required to allow electrons to flow

IV. Basic factors of electrical flow in a circuit

A. Current

(NOTE: Current is measured in amperes.)

B. Voltage

(NOTE: Voltage is measured in volts.)

C. Resistance

(NOTE: Resistance is measured in ohms.)

V. Relationship of voltage, amperage, and ohms to current flow

A. Voltage--The difference in electrical pressure measured between two points in a circuit

B. Amperage--The rate of electron flow

(NOTE: One ampere is 6.28 billion electrons passing a certain point in the conductor in one second.)

D. Ohm--Opposition (resistance) to current flow

INFORMATION SHEET

VI. Ohm's law--One volt is required to pass one ampere through one ohm of resistance (Transparency 2)

(NOTE: In the formula of Ohm's law, I = Amperage, E = Volts, and R = Ohms.)

VII. Calculating problems using Ohm's law (Transparency 2)

A. To find voltage (Assignment Sheet #1)

Voltage = Amperage x Resistance

Example:
E = I x R
E = 10 amperes x 12 ohms
E = 120 volts

B. To find amperage (Assignment Sheet #2)

Amperage = Voltage ÷ Resistance

Example:
I = E ÷ R
I = 120 volts ÷ 12 ohms
I = 10 amperes

C. To find resistance (Assignment Sheet #3)

Resistance = Voltage ÷ Amperage

Example:
R = E ÷ I
R = 120 volts ÷ 10 amperes
R = 12 ohms

VIII. Factors affecting resistance in a conductor

A. Material

(NOTE: Some materials have more resistance than others.)

B. Cross-section (size of conductor)

(NOTE: The larger the cross-section is, the lower the resistance will be.)

C. Length

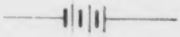
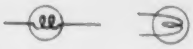
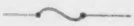
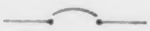
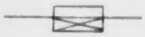
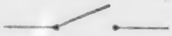
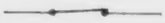
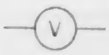
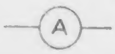
(NOTE: The longer the conductor is, the higher the resistance will be.)

D. Temperature

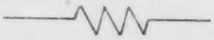
(NOTE: With most materials, the higher the temperature is, the greater the resistance will be.)

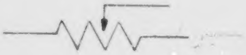
INFORMATION SHEET

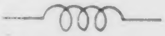
IX. Basic electrical symbols

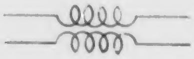
- A. Battery 
- B. Positive terminal +
- C. Negative terminal —
- D. Ground
- E. Lamp 
- F. Fuse 
- G. Circuit breaker 
- H. Fusible link or wire 
- I. Switch (open) 
- J. Switch (closed) 
- K. Voltmeter 
- L. Ammeter 
- M. Ohm Ω

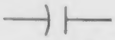
INFORMATION SHEET

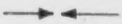
N. Resistor (fixed) 

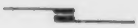
O. Variable resistor 

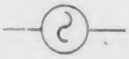
P. Coil 

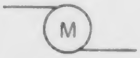
Q. Induction coil 

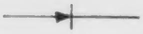
R. Condenser (capacitor) 

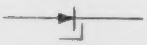
S. Spark gap 

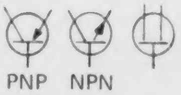
T. Contact points 

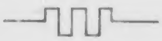
U. Alternator 

V. Motor (D.C.) 

W. Diodo (one-way) 

X. Zener diode 

Y. Transistor 

Z. Thermal element 

INFORMATION SHEET

X. Components of a basic electrical circuit (Transparency 3)

  A. Source

  B. Conductor

  C. Load

  D. Switch

XI. Types of electrical circuits (Transparency 4)

  A. Series

  (NOTE: In a series circuit the voltage will drop along the circuit. The total voltage drop in a series circuit will always be equal to the applied voltage.)

  B. Parallel

  (NOTE: The voltage will be the same at all points along a parallel circuit.)

  C. Series-parallel

  (NOTE: The circuit is a combination of a series circuit and a parallel circuit. It has medium resistance.)

XII. Instruments for testing electrical circuits (Transparency 5)

  A. Ammeter

  (NOTE: The ammeter measures volume of electrical flow in a circuit.)

  B. Voltmeter

  (NOTE: The voltmeter measures electrical pressure.)

  C. Ohmmeter

  (NOTE: The ohmmeter measures resistance to electrical flow in a circuit.)

XIII. Methods of connecting test instruments (Transparency 5)

  A. Ammeter--Connect in series with the circuit being tested and have current flowing when reading the meter

  B. Voltmeter--Connect in parallel with the circuit being tested

  (CAUTION: Do not connect a voltmeter to a circuit that may exceed the maximum voltage that the meter is capable of measuring.)

  C. Ohmmeter--Connect in series with circuit or portion of circuit being tested

  (CAUTION: The circuit should be DISCONNECTED from any current source when using an ohmmeter.)

INFORMATION SHEET

XIV. Basic electrical circuit failures (Transparency 6)

- A. Open circuit--Break in an electrical circuit which causes extremely high resistance

  (NOTE: Usually, no current will flow through an open circuit.)

- B. Shorted circuit--Unwanted connection, usually copper to copper, that allows current to bypass all or part of the circuit
- C. Grounded circuit--Unwanted connection that bypasses all or part of the circuit from the insulated side to the grounded side of the circuit

  (NOTE: A grounded circuit is usually a copper-to-iron connection.)

- D. High resistance circuit--Failure caused by poor or corroded connections or damaged wires which reduce current flow in the circuit

XV. Characteristics of magnetism (Transparency 7)

- A. Magnets have a north and south pole
- B. Lines of force are exerted between the poles in a concentric form
- C. The lines of force move from north to south pole on the outside of the magnet
- D. The lines of force move from south to north on the inside of the magnet
- E. The lines of force tend to parallel each other
- F. Like poles repel each other
- G. Unlike poles attract each other

XVI. Characteristics of electromagnetism (Transparency 8)

- A. An electromagnet has the same characteristics as a permanent magnet
- B. A magnetic field is established around a conductor that is carrying current
- C. The electromagnet gets strength as more current flows through the coils or as the coils are increased in number
- D. An iron core inside the coil will increase the strength of magnetism by concentrating lines of force

INFORMATION SHEET

XVII. Electromagnet induction

A. Voltage will be induced in a conductor that cuts across a magnetic field when there is relative motion between the field and conductor

B. Either the conductor or magnetic field may move

C. Induction occurs when changing current in one coil induces voltage in an adjacent second coil

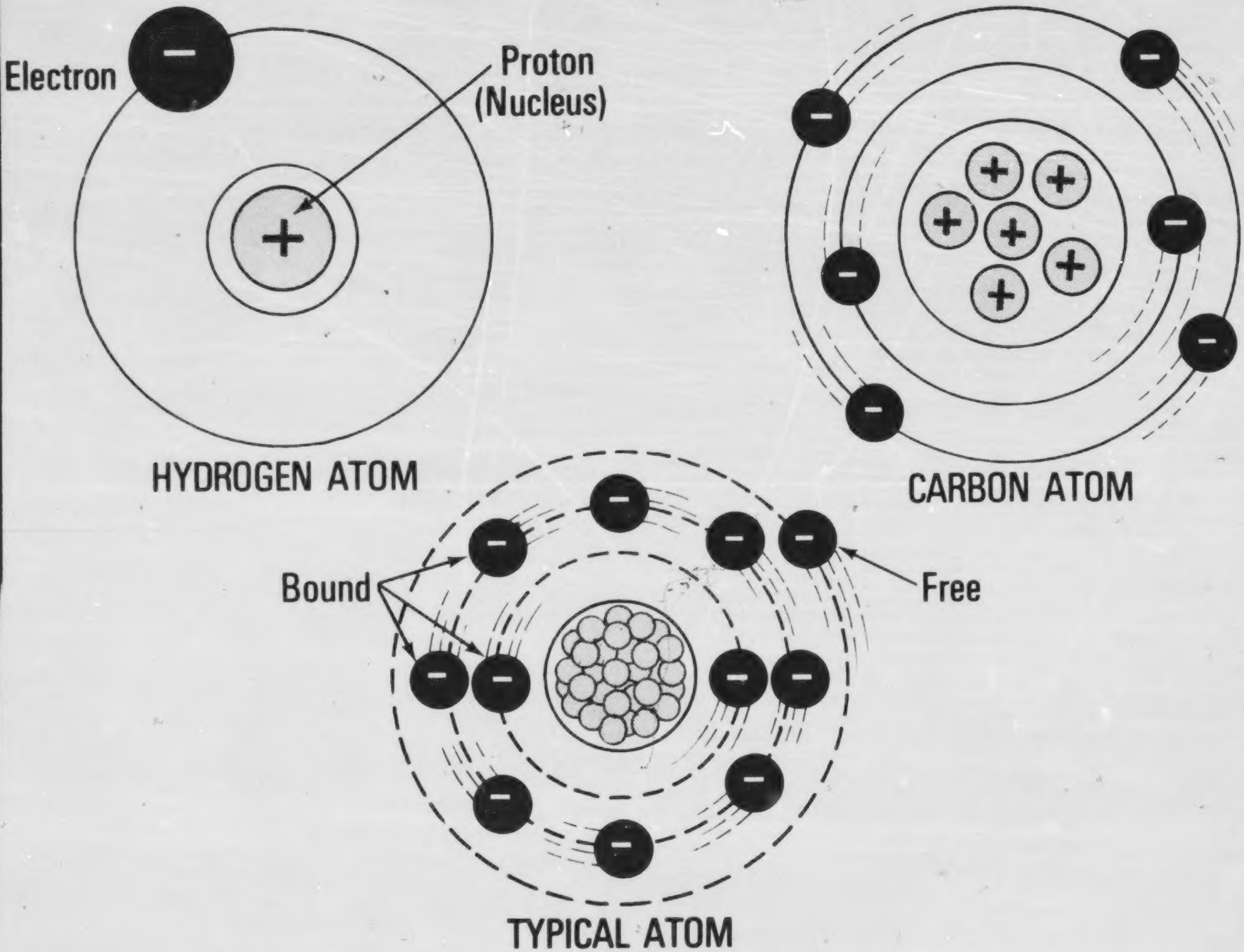
XVIII. Factors determining magnitude of induced voltage

A. Strength of magnetic field

B. Speed at which lines of force cut across conductor

C. Number of conductors cutting across lines of force

Atomic Structure

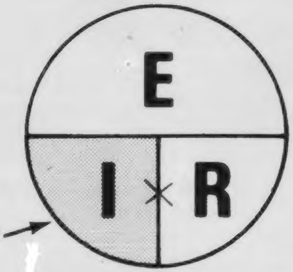

Electron
Proton
(Nucleus)
HYDROGEN ATOM
CARBON ATOM
Bound
Free
TYPICAL ATOM

Ohm's Law

In the formula of Ohm's law, I = amperage, E = voltage, and R = resistance in ohms.

(Note: If you cover the quantity you wish to calculate (voltage, current, or resistance), the remaining parts of the memory circle will show you which form of Ohm's law you must use:)

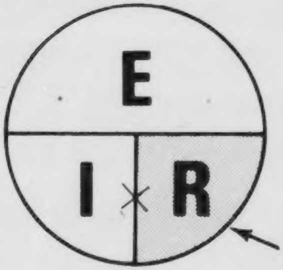
$$\text{Amperes} = \frac{\text{Volts}}{\text{Ohms}}$$



Cover up "I"

$$I = \frac{E}{R}$$

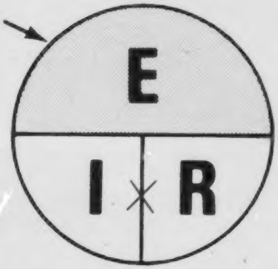
$$\text{Ohms} = \frac{\text{Volts}}{\text{Amperes}}$$



Cover up "R"

$$R = \frac{E}{I}$$

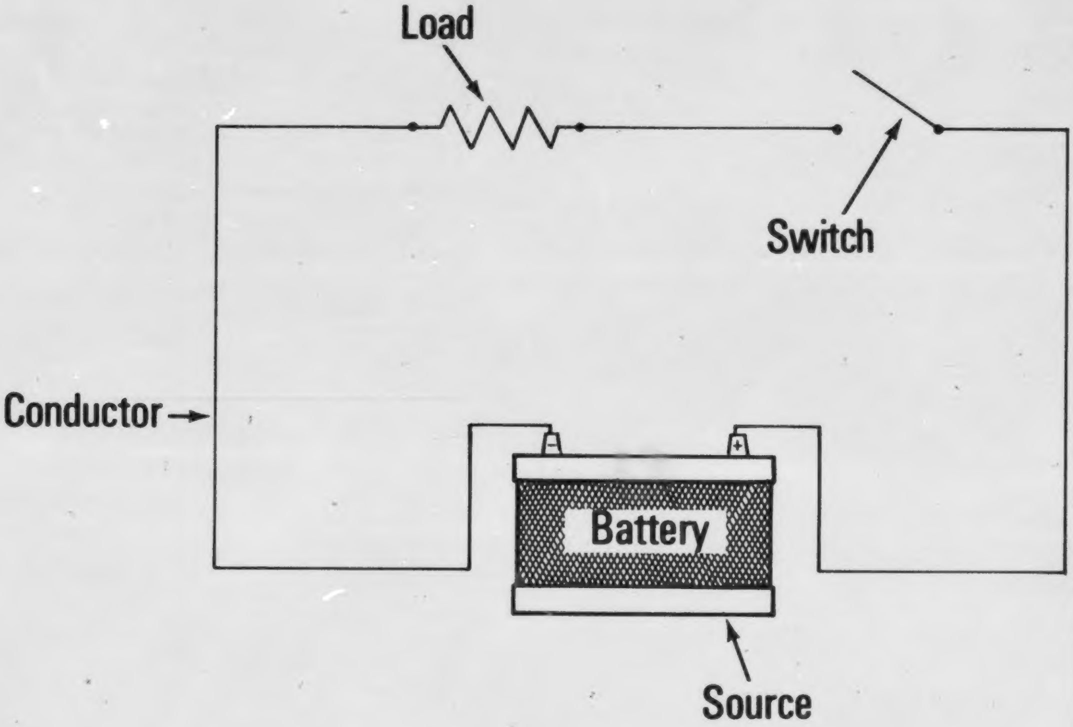
Cover up "E"



Volts = Amperes × Ohms

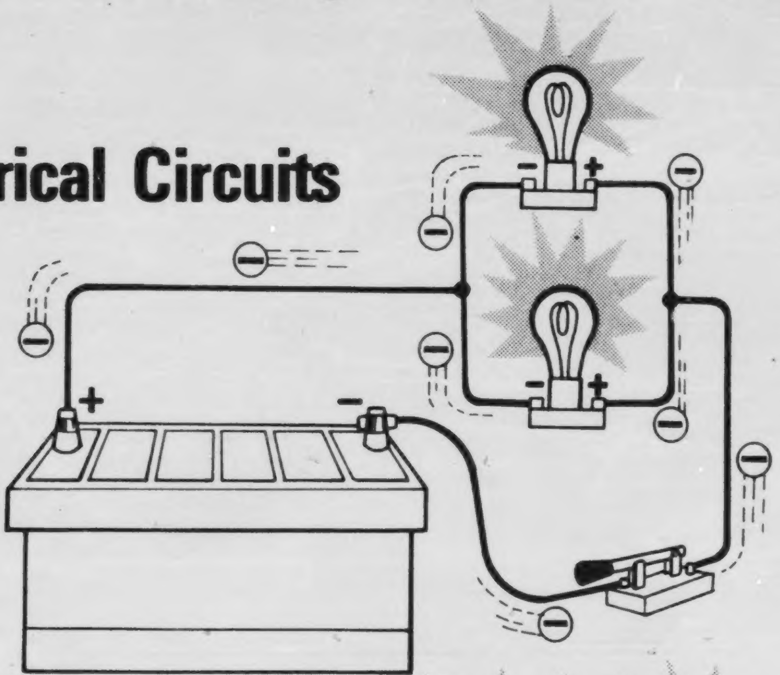
$E = I \times R$

Basic Circuit

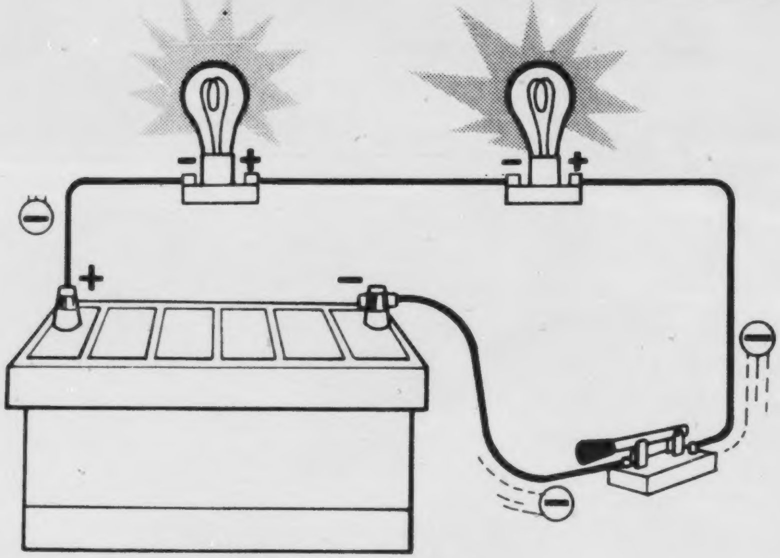

Load
Switch
Conductor
Battery
−
+
Source

TM 3

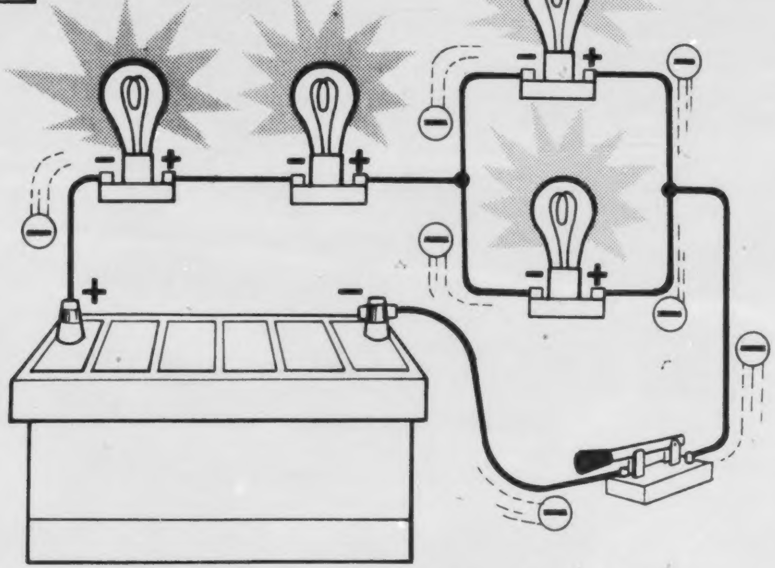
Types of Electrical Circuits



Parallel Circuit

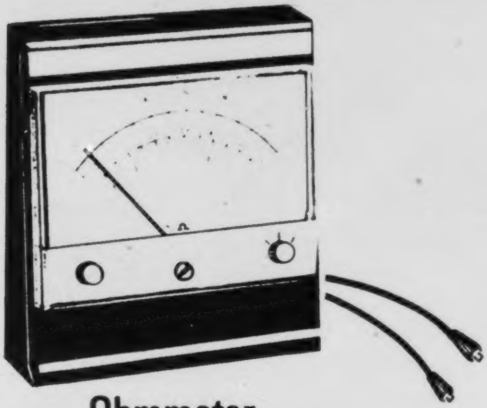


Series Circuit

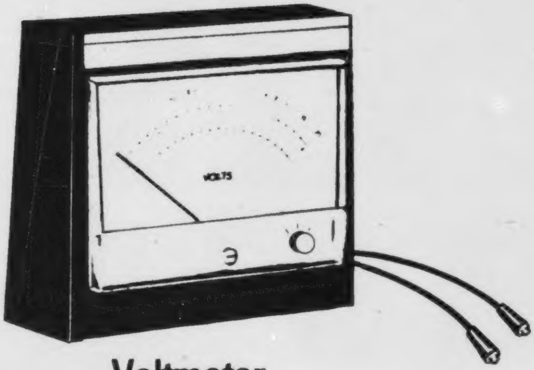


Series-Parallel Circuit

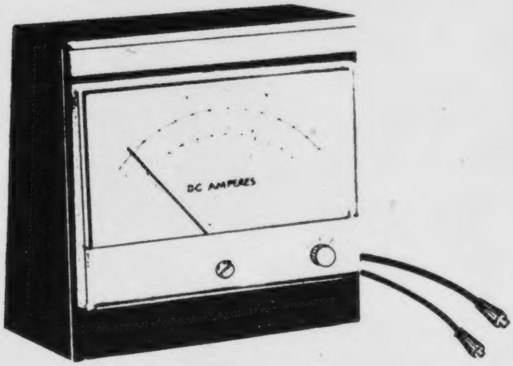
Test Instruments



Ohmmeter

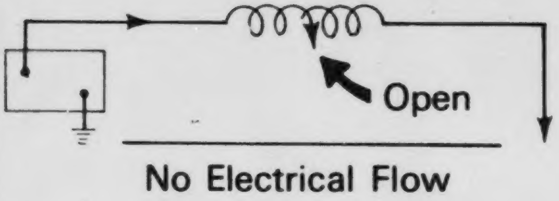


Voltmeter

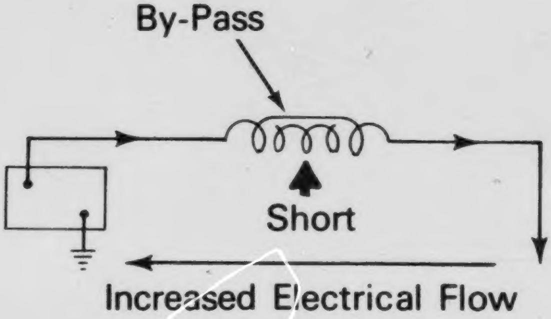


Ammeter

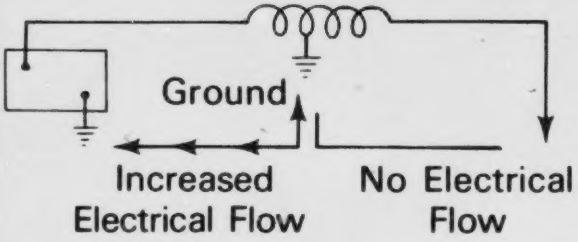
Causes of Electrical Failures


Open
No Electrical Flow

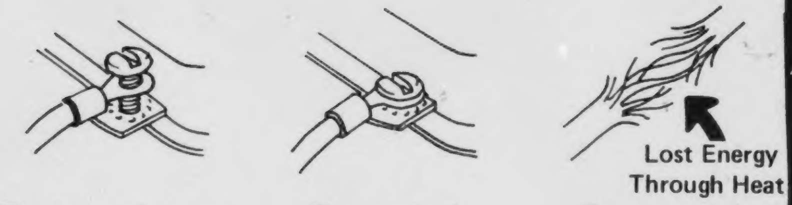
Open Circuit


By-Pass
Short
Increased Electrical Flow

Shorted Circuit


Ground
Increased Electrical Flow
No Electrical Flow

Grounded Circuit


Lost Energy Through Heat

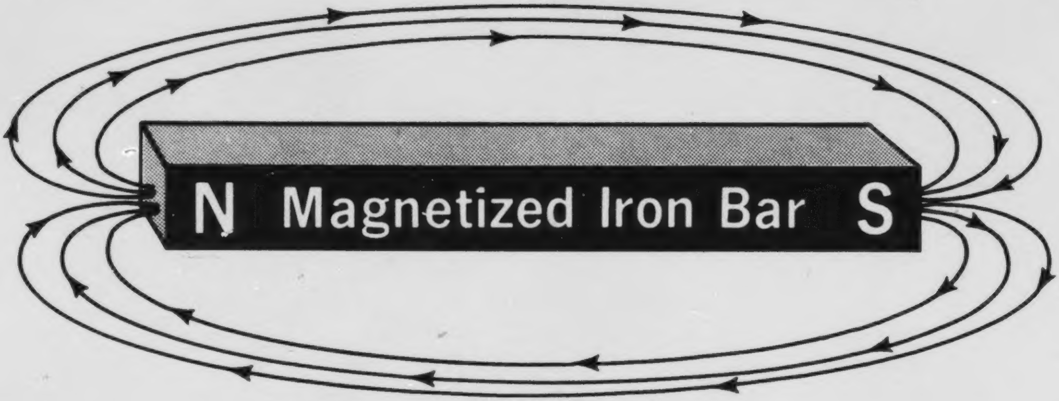
Poor or Loose Connections

Corroded Connections

Damaged Wires

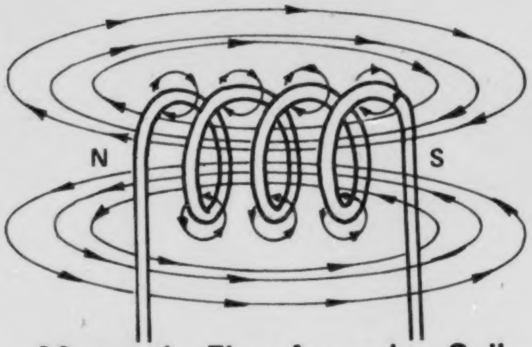
High Resistance Circuit

Magnet

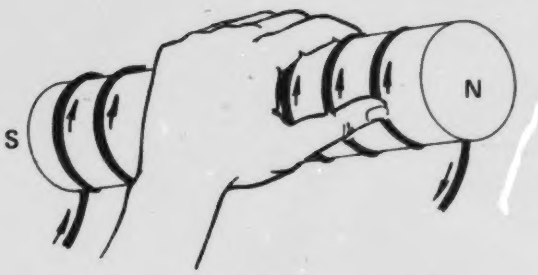

N
Magnetized Iron Bar
S

Magnetic Lines of Force or Magnetic Field

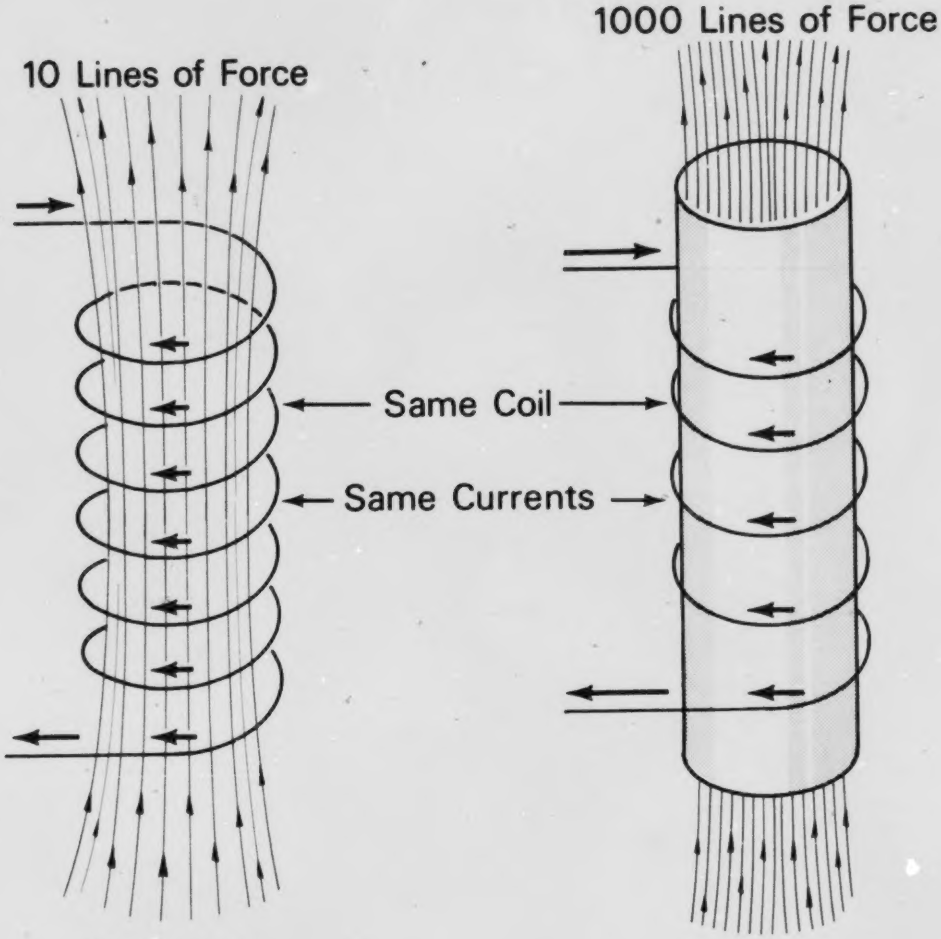
Electromagnetism



Magnetic Flux Around a Coil



Lefthand Rule for a Coil


10 Lines of Force
1000 Lines of Force
Same Coil
Same Currents

Air Core or Nonmagnetic Material

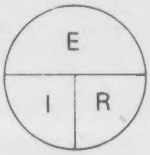
Iron Core or Magnetic Material

BASIC ELECTRICAL THEORY
UNIT I

ASSIGNMENT SHEET #1--CALCULATE VOLTAGE USING OHM'S LAW

Calculate voltage in the problems listed below using the correct form of Ohm's law.

$E = I \times R$



1.

	Amperes	Ohms	Volts
a.	0.005	16,000	_____
b.	20	15	_____
c.	5	365	_____
d.	0.023	6.3	_____
e.	7.5	1.6	_____

2. A relay requires a current of 0.050 amperes to close its switch contacts. Its coil has a resistance of 240 ohms. How much voltage is needed?

3. How much voltage must be applied to the 50-ohm heating element of a soldering iron that requires a current of 2.3 amperes to reach proper temperature?

4. A transistor radio with an internal resistance of 200 ohms requires a current of 0.03 amperes for its operation. What battery voltage is needed?

5. A light bulb with a resistance of 10 ohms needs a 1.2 ampere current for full brilliancy. Calculate the voltage required.

ASSIGNMENT SHEET #1

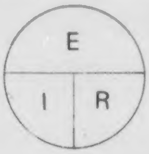
6. Calculate the battery voltage needed to drive a current of 150 amperes through the starter of a car. The starter's resistance is 0.08 ohms.

BASIC ELECTRICAL THEORY
UNIT I

ASSIGNMENT SHEET #2--CALCULATE CURRENT FLOW IN AMPERES USING OHM'S LAW

Calculate the current flow in amperes in the problems listed below using the correct mathematical procedures.

$$I = \frac{E}{R}$$



1.

	Volts	Ohms	Amperes
a.	0.2	16	________
b.	6	18	________
c.	12.6	3.5	________
d.	12	0.5	________
e.	9	55	________

2. Calculate the amperage in a circuit with a 4-ohm resistor when connected to a 12-volt battery.

3. A transistor radio with an internal resistance of 600 ohms is operated with a 12-volt battery. How much current must the battery supply?

4. A soldering iron has a resistance of 200 ohms. How much current will it draw from a 115-volt line?

5. The starter of an automobile has a resistance of 0.12 ohms. How much current must a 12.6-volt storage battery supply to start the car?

ASSIGNMENT SHEET #2

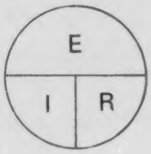
6. A fan motor in an automobile air conditioner has an internal resistance of 180 ohms and a 12-volt battery. What will be the amperage draw of the motor?

BASIC ELECTRICAL THEORY
UNIT I

ASSIGNMENT SHEET #3--CALCULATE RESISTANCE USING OHM'S LAW

Calculate the amount of resistance in the problems listed below, using the correct form of Ohm's law.

$$R = \frac{E}{I}$$



1.

	Volts	Amperes	Ohms
a.	115	0.30	_____
b.	12	4.0	_____
c.	6	2.5	_____
d.	9.6	0.25	_____
e.	10.0	160	_____

2. A 12-volt battery causes an electrical current of 1.25 amperes to flow through a car radio. Calculate the radio's internal resistance.

3. Calculate the internal resistance of an ignition coil with a current draw of 7.5 amperes of 12 volts.

4. Calculate the resistance of an automobile headlight that needs a current of 3 amperes and a supply voltage of 12.6 volts.

5. An automobile horn has a current draw of 4.8 amperes with a battery voltage of 12.4 volts. What is the internal resistance of the horn?

ASSIGNMENT SHEET #3

6. An ignition resistance unit supplies the ignition system with 2.7 amperes of current at 9 volts. What is the ohms of resistance in the unit?

BASIC ELECTRICAL THEORY
UNIT I

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. a. 80 volts
   b. 300 volts
   c. 1825 volts
   d. 0.1449 volts
   e. 12 volts
2. 12 volts
3. 115 volts
4. 6 volts
5. 12 volts
6. 12 volts

Assignment Sheet #2

1. a. 0.013 amperes
   b. 0.333 amperes
   c. 3.6 amperes
   d. 24 amperes
   e. 0.164 amperes
2. 3.0 amperes
3. 0.02 amperes
4. 0.575 amperes
5. 105 amperes
6. 0.067 amperes

BASIC ELECTRICAL THEORY
UNIT I

JOB SHEET #1--CONSTRUCT A SERIES CIRCUIT

I. Tools and materials

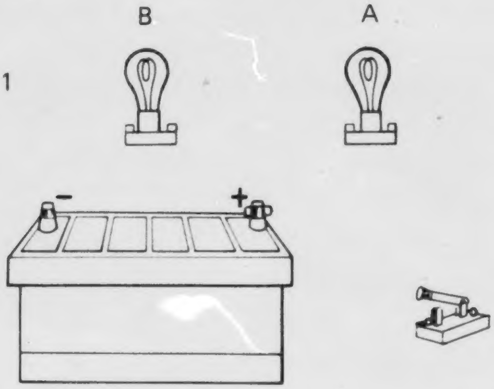
- A. 12-volt battery
- B. Voltmeter
- C. Single lead light sockets, 2
- D. Bulbs to fit the light sockets, 2
- E. Single-pole toggle switch
- F. Assortment of jumper leads
- G. Circuit board or mounting board

II. Procedure

- A. Attach two light sockets to the circuit board (Figure 1)
- B. Install bulbs into the light sockets (Figure 1)
- C. Attach switch to circuit board (Figure 1)
- D. Position the battery close to the circuit board (Figure 1)

  (CAUTION: Avoid any arcing around the battery. Avoid personal contact with battery acid.)

FIGURE 1



- E. Place the switch in the Off position

JOB SHEET #1

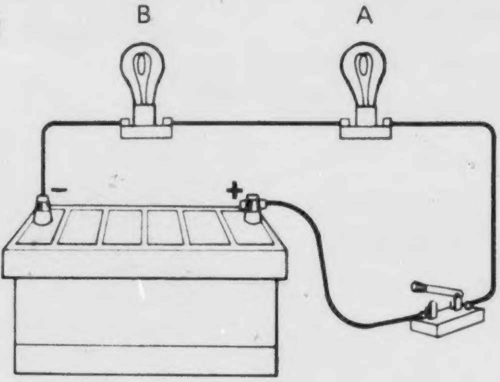
F. Connect a jumper lead between the switch and the wire from light socket A (Figure 2)

G. Connect a jumper lead from the base of light socket A to the wire of socket B (Figure 2)

H. Connect a jumper lead from the base of socket B to the negative post of the battery (Figure 2)

I. Connect a jumper lead from the remaining terminal of the switch to the positive post of the battery (Figure 2)

FIGURE 2



J. Move the switch to the On or closed position

(NOTE: Both bulbs will light, but at about half their normal intensity.)

K. Remove either bulb

(NOTE: The other bulb will go out.)

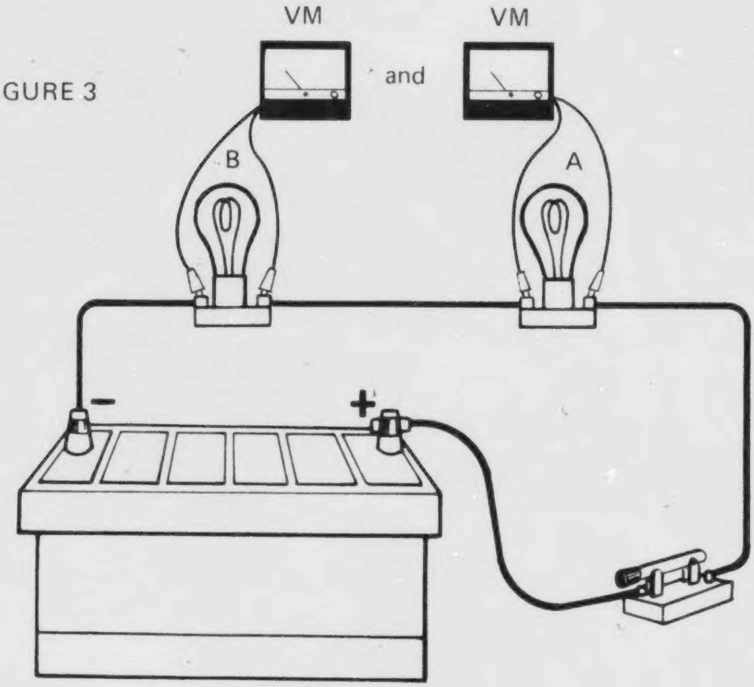
L. Install the removed bulb

JOB SHEET #1

M. Connect a voltmeter across connections of light socket A and take voltage reading; repeat for light socket B (Figure 3)

(NOTE: The voltage drop reading for each is one-half the battery voltage.)

FIGURE 3



Principle: In a series circuit the voltage will drop along the circuit. The total drop in a series circuit will always be equal to the applied voltage.

BASIC ELECTRICAL THEORY
UNIT I

JOB SHEET #2--CONSTRUCT A PARALLEL CIRCUIT

I. Tools and materials

  A. 12-volt battery

  B. Voltmeter

  C. Single-lead light sockets, 2

  D. 12-volt bulbs to fit light sockets, 2

  E. Single-pole toggle switch

  F. Assortment of jumper leads

  G. Circuit board or mounting board

II. Procedure

  A. Attach two light sockets to the circuit board (Figure 1)

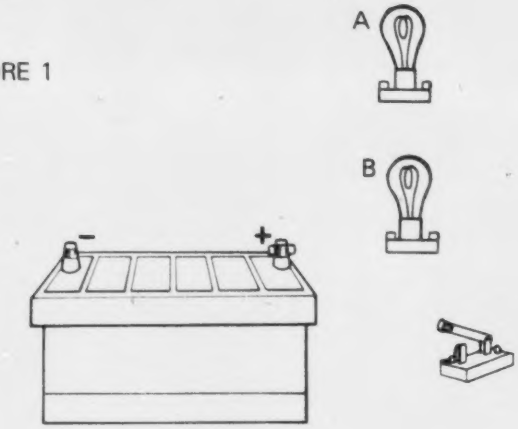
  B. Install bulbs into the light sockets (Figure 1)

  C. Attach switch to circuit board (Figure 1)

  D. Position the battery close to the circuit board (Figure 1)

  (CAUTION: Avoid arcing around the battery. Avoid personal contact with battery acid.)

FIGURE 1



  E. Place the switch in the Off position

  F. Connect a jumper lead (J1) between the leads on bulbs A and B (Figure 2)

JOB SHEET #2

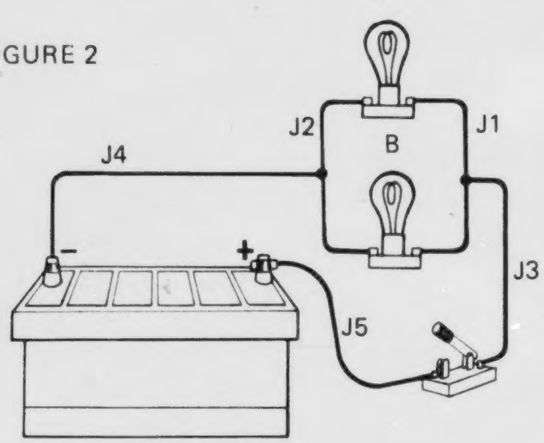
G. Connect a jumper lead (J2) between the base of socket A and B (Figure 2)

H. Connect a jumper lead (J3) from switch terminal to jumper lead J1 (Figure 2)

I. Connect a jumper lead (J4) between jumper lead J2 and battery negative terminal (Figure 2)

J. Connect a jumper lead (J5) to switch terminal then to battery positive terminal (Figure 2)

FIGURE 2



K. Move the switch to the On or closed position

(NOTE: Both bulbs will light at normal intensity.)

L. Remove either bulb

(NOTE: The remaining bulb will light at its normal intensity.)

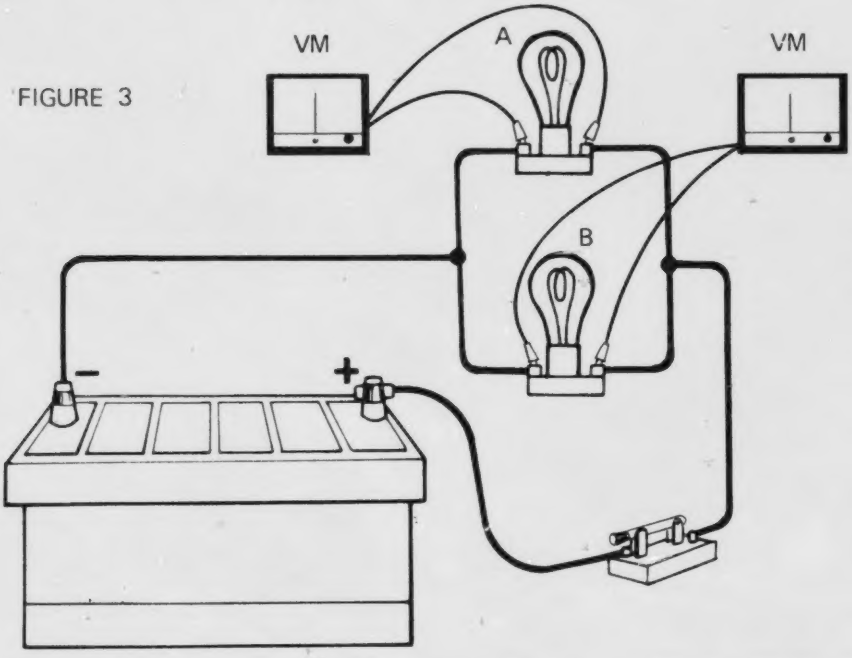
M. Install the removed bulb

JOB SHEET #2

N. Connect a voltmeter across connections of light socket A and take voltage reading; repeat for light socket B (Figure 3)

(NOTE: The readings should be the same as the battery voltage.)

FIGURE 3



Principle: The voltage will be the same at all points along a parallel circuit

BASIC ELECTRICAL THEORY
UNIT I

TEST

NAME ______________________________ SCORE ____________________

1. Match the terms on the right to the correct definitions. (Answers for "a" through "l" are on this page.)

______a. Negatively charged particle that circles the nucleus of an atom

______b. Material that resists the flow of electrical current

______c. Object that converts electrical energy into heat, light, or mechanical energy

______d. Steady flow of electrons moving continually in the same direction along a conductor from a point of high potential to one of lower potential

______e. Collective term applied to the positive and negative ends of a magnet or the direction of current flow in a circuit

______f. Force which tends to cause a flow of electricity which is measured in volts

______g. Smallest particle into which an element can be divided

______h. Atom with too few electrons

______i. Any material which allows electrical current to flow through easily

______j. Continuous path along a conductor through which electrical current can flow from a source, through a load, and back to the source

______k. Atom with too many electrons

______l. Positively charged particle in the nucleus of an atom

1. Atom
2. Polarity
3. Load (consumer)
4. Insulator
5. Proton
6. Direct current (D.C.)
7. Positively charged atom
8. Electron
9. Conductor
10. Electromotive force
11. Negatively charged atom
12. Circuit

______m. Flow of electrons measured in amperes

______n. Flow of electrons which reverses its direction of flow at intervals in a conductor

______o. That area near a magnet in which its property of magnetism can be detected

______p. Atom or group of atoms that carries a positive or negative electrical charge as a result of having lost or gained electrons

______q. Material which has the property of attracting iron or other magnets

______r. Alternate name for the magnetic lines of force existing in the space around a permanent magnet or electromagnet

13. Magnetic field
14. Alternating current (A.C.)
15. Current
16. Magnet
17. Ion
18. Flux lines

2. Match the parts of an atom to the correct electrical values.

______a. Positive charge

______b. Negative charge

1. Proton
2. Electron

3. Describe electricity according to the electron theory.

____

____

____

____

4. State the basic factors of electrical flow in a circuit.

a. ____

b. ____

c. ____

5. Discuss the relationship of voltage, amperage, and ohms to current flow.

____

____

____

6. State Ohm's law.

____

____

7. Calculate the following problems using Ohm's law.

   a. Find the voltage when:

      I = 3 and R = 4 E = __________

   b. Find the amperage when:

      E = 12 and R = 3 I = __________

   c. Find the resistance when:

      E = 480 and I = 10 R = __________

8. List four factors which affect resistance in a conductor.

   a. _______________________________________

   b. _______________________________________

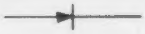
   c. _______________________________________

   d. _______________________________________

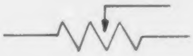
9. Identify the following basic electrical symbols by writing the correct names in the blanks provided.

+

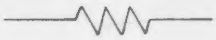
a. ______________



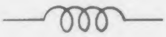
b. ______________



c. ______________



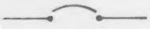
d. ______________



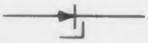
e. ______________

−

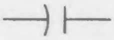
f. ______________



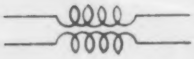
g. ______________



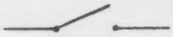
h. ______________



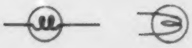
i. ______________



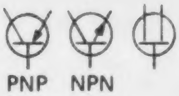
j. ____________________



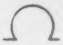
k. ____________________



l. ____________________

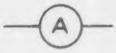


m. ____________________

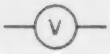


n. ____________________

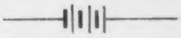
o. ____________________



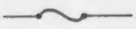
p. ____________________



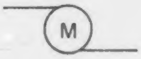
q. ____________________



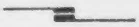
r. ____________________



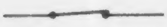
s. ____________________



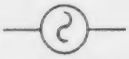
t. ____________________



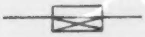
u. ____________________



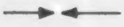
v. ____________________



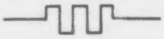
w. ____________________



x. ____________________



y. ____________________



z. ____________________

10. List the components of a basic electrical circuit.

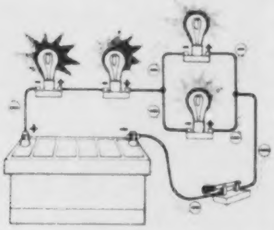
a. ____

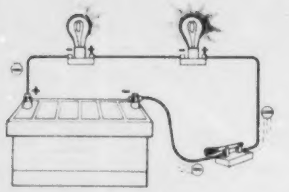
b. ____

c. ____

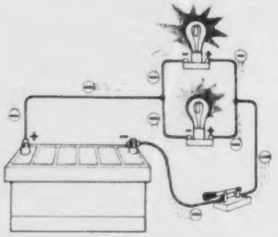
d. ____

11. Identify the following types of electrical circuits.



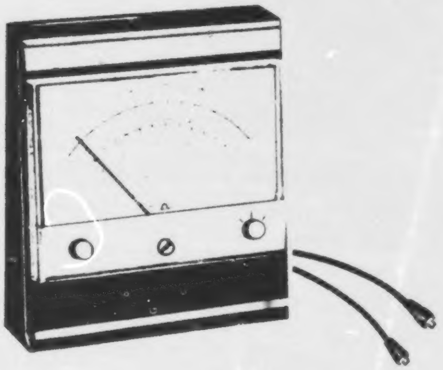


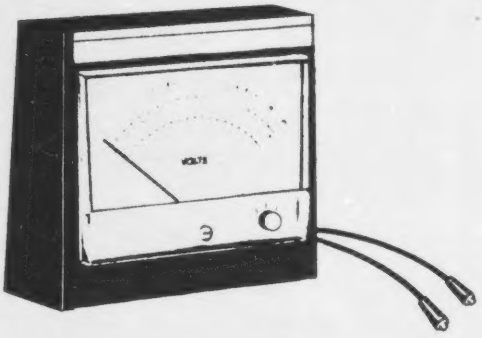
a. ______________________ b. ______________________



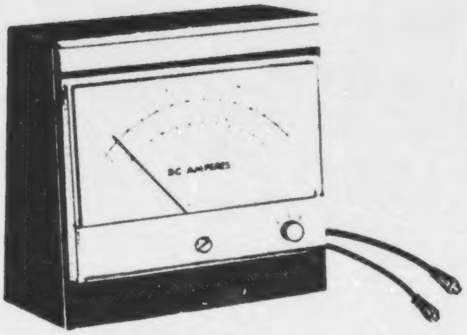
c. ______________________

12. Identify the following instruments used for testing electrical circuits.





a. ______________________ b. ______________________



c. ______________________

13. Match the test instruments on the right to the correct methods of connecting them.

______a. Connect in parallel with the circuit being tested

______b. Connect in series with the circuit being tested and have current flowing when reading the meter

______c. Connect in series with circuit or portion of circuit being tested

1. Ammeter
2. Voltmeter
3. Ohmmeter

14. Match the basic electrical circuit failures on the right to the correct causes.

______a. Break in an electrical circuit which causes extremely high resistance

______b. Unwanted connection, usually copper to copper, that allows current to bypass all or part of the circuit

______c. Unwanted connection that bypasses all or part of the circuit from the insulated side to the grounded side of the circuit

______d. Failure caused by poor or corroded connections or damaged wires which reduce current flow in the circuit

1. Shorted circuit
2. High resistance circuit
3. Grounded circuit
4. Open circuit

15. Select from the list below the characteristics of magnetism. Place an "X" in the correct blanks.

_____a. The lines of force move from north to south pole on the outside of the magnet

_____b. Magnets have a north and south pole

_____c. Unlike poles attract each other

_____d. The lines of force move from south to north pole on the outside of the magnet

_____e. The lines of force tend to parallel each other

_____f. The lines of force intersect at right angles

_____g. Like poles repel each other

_____h. The lines of force move from south to north on the inside of the magnet

_____i. Lines of force are exerted between the poles in a concentric form

16. Select from the list below the characteristics of electromagnetism by placing an "X" in the blanks provided.

_____a. An iron core inside the coil will increase the strength of magnetism by concentrating lines of force

_____b. Magnetic lines of force reverse direction when an iron core is used inside the coil

_____c. An electromagnet has the same characteristics as a permanent magnet

_____d. A magnetic field is established around a conductor that is carrying current

_____e. An electromagnet will eventually become permanently magnetized when used too often

_____f. The electromagnet gets strength as more current flows through the coils or as the coils are increased in number

17. Describe electromagnet induction.

____

____

____

____

____

18. List three factors which determine magnitude of induced voltage.

a. ____

b. ____

c. ____

19. Demonstrate the ability to:

a. Construct a series circuit.

b. Construct a parallel circuit.

(NOTE: If these have not been accomplished prior to the test, ask the instructor when the above activities should be completed.)

BASIC ELECTRICAL THEORY
UNIT I

ANSWERS TO TEST

1. a. 8
   b. 4
   c. 3
   d. 6
   e. 2
   f. 10
   g. 1
   h. 7
   i. 9
   j. 12
   k. 11
   l. 5
   m. 15
   n. 14
   o. 13
   p. 17
   q. 16
   r. 18

2. a. 1
   b. 2

3. Description should include:

   a. Electrons move through a conductor from negative to positive

   b. Some type of force (voltage) is needed to cause the free electrons to move from atom to atom

   c. Complete circuit is required to allow electrons to flow

4. a. Current
   b. Voltage
   c. Resistance

5. Discussion should include:

   a. Voltage--The difference in electrical pressure measured between two points in a circuit

   b. Amperage--The rate of electron flow

   c. Ohm--Opposition (resistance) to current flow

6. One volt is required to pass one ampere through one ohm resistance

7. a. 12
   b. 4
   c. 48

8. a. Material
   b. Cross-section (size of conductor)
   c. Length
   d. Temperature

9. a. Positive terminal
   b. Diode (one-way)
   c. Variable resistor
   d. Resistor (fixed)
   e. Coil
   f. Negative terminal
   g. Circuit breaker
   h. Zener diode
   i. Condenser (capacitor)
   j. Induction coil
   k. Switch (open)
   l. Lamp
   m. Transistor
   n. Ohm
   o. Ground
   p. Ammeter
   q. Voltmeter
   r. Battery
   s. Fuse
   t. Motor (D.C.)
   u. Contact points
   v. Switch (closed)

w. Alternator

x. Fusible link or wire

y. Spark gap

z. Thermal element

10. a. Source

b. Conductor

c. Load

d. Switch

11. a. Series-parallel

b. Series

c. Parallel

12. a. Ohmmeter

b. Voltmeter

c. Ammeter

13. a. 2

b. 1

c. 3

14. a. 4

b. 1

c. 3

d. 2

15. a, b, c, e, g, h, i

16. a, c, d, f

17. Description should include:

a. Voltage will be induced in a conductor that cuts across a magnetic field when there is relative motion between the field and conductor

b. Either the conductor or magnetic field may move

c. Induction occurs when changing current in one coil induces voltage in an adjacent second coil

18. a. Strength of magnetic field
    b. Speed at which lines of force cut across conductor
    c. Number of conductors cutting across lines of force
19. Performance skills evaluated to the satisfaction of the instructor

BATTERY SERVICE
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to list the functions of a battery and select from a list the processes by which it converts chemical energy into electrical energy. The student should be able to select safety rules from a list, explain battery ratings, and demonstrate the ability to service and load test a battery. This knowledge will be evidenced through demonstration and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with batteries to the correct definitions.
2. List the functions of the battery.
3. Match the parts of the battery to the correct purposes.
4. Select from a list the processes by which a battery converts chemical energy into electrical energy.
5. List factors affecting battery voltage and capacity.
6. Match the types of battery ratings to the correct descriptions.
7. Select from a list safety rules to be observed during the care and maintenance of batteries.
8. Describe the features of a service-free battery.
9. Demonstrate the ability to:
    a. Clean and service a battery.
    b. Remove and replace a battery.
    c. Measure battery electrolyte with a hydrometer.
    d. Load test a battery.
    e. Charge test a battery for three minutes.

BATTERY SERVICE
UNIT II

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss procedures outlined on the job sheets.

   G. Give test.

II. Unit references:

   A. *Electrical Systems.* Fundamentals of Service Series. Moline, Illinois: Deere and Co., 1968.

   B. Billiet, Walter E., and Goings, Leslie F. *Automotive Electrical Systems.* 3rd ed. Chicago: American Technical Society, 1970.

   C. Crouse, William H. *Automotive Mechanics.* 7th ed. New York: Webster Div./McGraw-Hill Book Co., 1975.

   D. Crouse, William H. *Automotive Electrical Equipment.* 8th ed. New York: McGraw-Hill Book Co., 1976.

   E. *Chrysler, Plymouth, Dodge Electrical Service Manual.* Detroit: Chrysler Corp., 1976.

   F. *Chevrolet Chassis Overhaul Manual.* Detroit, Michigan: Chevrolet Motor Div./General Motors Corp., 1974.

   G. *Ford Electrical Car Shop Manual.* Dearborn, Michigan: Ford Motor Co., 1975-76.

BATTERY SERVICE
UNIT II

INFORMATION SHEET

I. Terms and definitions

A. Battery--Two or more connected cells which convert chemical energy into electrical energy (Transparency 1)

B. Cell--One positive plate group and one negative plate group (Transparency 2)

(NOTE: The positive plate contains lead peroxide and the negative plate contains spongy lead.)

C. Plate group--Similar plates welded to a plate strap (Transparency 2)

(NOTE: Plate groups are interlaced, with positive and negative plates alternating but separated to allow free flow of electrolyte.)

D. Electrolyte--Solution of water and sulfuric acid, usually at a ratio of 60% to 40% respectively

E. Specific gravity--Weight of liquid compared to an equal volume of distilled water

(NOTE: Water has a specific gravity of 1.000.)

F. Hydrometer--Glass barrel syringe containing a calibrated float used to measure specific gravity

G. Sulfated--Oxidation of positive plate grid wires and formation of lead sulfate crystals on the lead peroxide material

(NOTE: This sulfated condition is caused by long storage without recharging. A slow charge may or may not restore the battery.)

H. Dissimilar metals--Metals not alike in substance or essentials

I. Battery rating--Capacity rated according to the quantity of electricity that can be taken from a fully charged battery over a definite period of time

II. Functions of a battery

A. To supply current for cranking the engine

B. To supply current when the demand exceeds the output of the charging system

C. To stabilize the voltage in the system during operation

INFORMATION SHEET

III. Purpose of battery parts (Transparency 1)

A. Plate--Stores active material which brings about a chemical reaction to provide electricity

B. Separator--Insulates the negative plate from the positive plate

C. Terminal post--Provides a low resistance connection for the battery cable

(NOTE: Positive post is larger than negative post. Some batteries have side mounted cable terminals.)

D. Battery case--Holds the cells and electrolyte to make up the completed battery

E. Vent cap--Closes the opening in each cell cover and provides a vent to allow gases to escape (Transparency 3)

(NOTE: Service-free batteries do not have removable vent caps, but they do have vents with spark arrestors.)

F. Cell connector--Connects cells in series

(NOTE: Six-volt batteries have three cells and twelve-volt batteries have six cells connected in series.)

G. Post plate strap--Connects plate group to terminal post

IV. Converting chemical energy into electrical energy (Transparency 4)

A. Two dissimilar metals placed in acid solution will produce chemical action

B. The more active metal will lose electrons and become positively charged

C. The less active metal will accumulate electrons and become negatively charged

V. Factors affecting battery voltage and capacity

A. Battery voltage

1. All cells contain only two volts

2. Battery voltage can be changed by adding or subtracting cells that are connected in series

(NOTE: Battery voltage is determined by multiplying the number of cells by two volts.)

INFORMATION SHEET

B. Battery capacity (in amperes)

1. The number of plates
2. The area of plate material
3. The strength of the electrolyte

VI. Types of battery ratings

A. Ampere-hour rating (reserve capacity rating)--Length of time in minutes that a fully charged battery at 80°F (26.7°C) can deliver a specific quantity of current

Example: 20 amperes for 120 minutes

$$20 \times \frac{120}{60} = 40 \text{ ampere-hour units}$$

B. Cold cranking rating--Number of amperes that a battery can deliver for 30 seconds at 0°F (-17.8°C) without the cell voltage dropping below 1.2 volts

C. Peak watt rating (PWR)--Measure of the battery's cold cranking ability determined by multiplying the maximum current by the maximum voltage the battery is capable of producing

(NOTE: The numerical rating is embossed on the case at the base of the battery.)

(CAUTION: The peak watt rating should not be confused with the ampere-hour rating since two batteries with the same ampere-hour rating could have quite different watt ratings.)

VII. Safety rules

A. Do not allow battery electrolyte to come in contact with clothing, skin, eyes, or painted surfaces

B. Keep flames or sparks away from battery because gases given off by the battery are very explosive

(NOTE: The battery gives off hydrogen and oxygen.)

C. Avoid shorting or grounding battery terminals during service

D. Wear safety goggles, rubber gloves, and rubber apron when servicing batteries

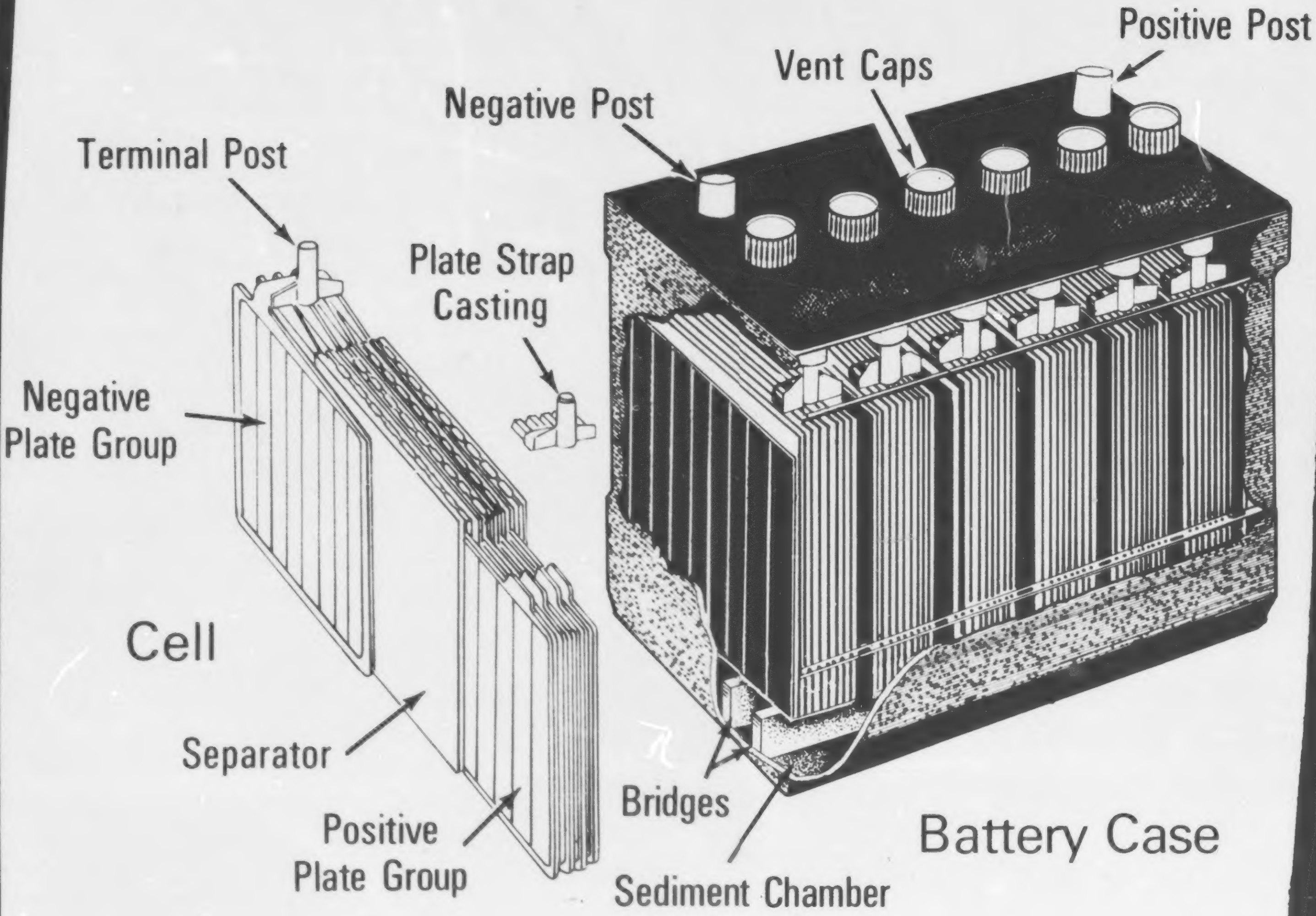
INFORMATION SHEET

- E. Flush immediately with water any area of skin which acid has contacted
- F. Avoid breathing fumes from a battery that is being charged

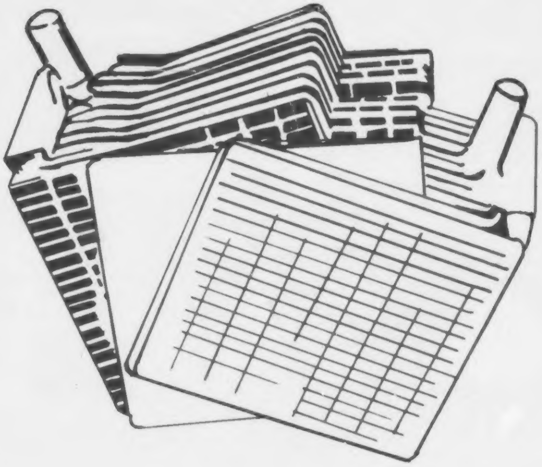
VIII. Features of service-free battery (Transparency 5)

- A. Case sealed with lifetime supply of electrolyte
- B. Special liquid-gas separator which returns liquid to reservoir
- C. Special plate material which drastically reduces
    1. Water loss from the charging process
    2. Self-discharge while battery is not in use
    3. Overcharge when used in high temperatures

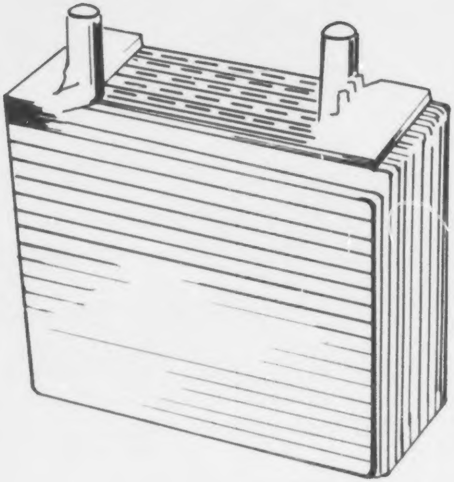
Storage Battery Construction


Positive Post
Vent Caps
Negative Post
Terminal Post
Plate Strap
Casting
Negative
Plate Group
Cell
Separator
Positive
Plate Group
Bridges
Sediment Chamber
Battery Case

Battery Plate Groups


Positive
Plate Group
Negative
Plate Group

Separator



Element or Cell

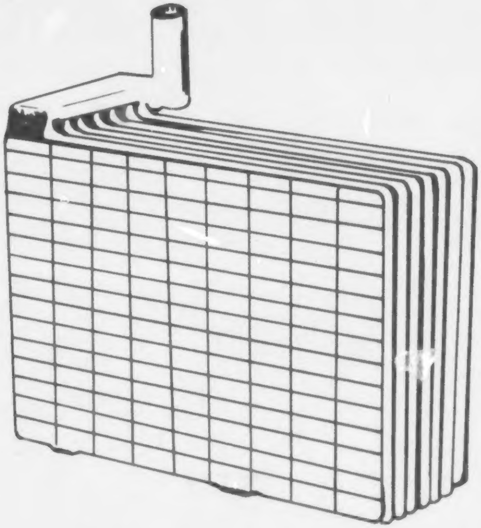
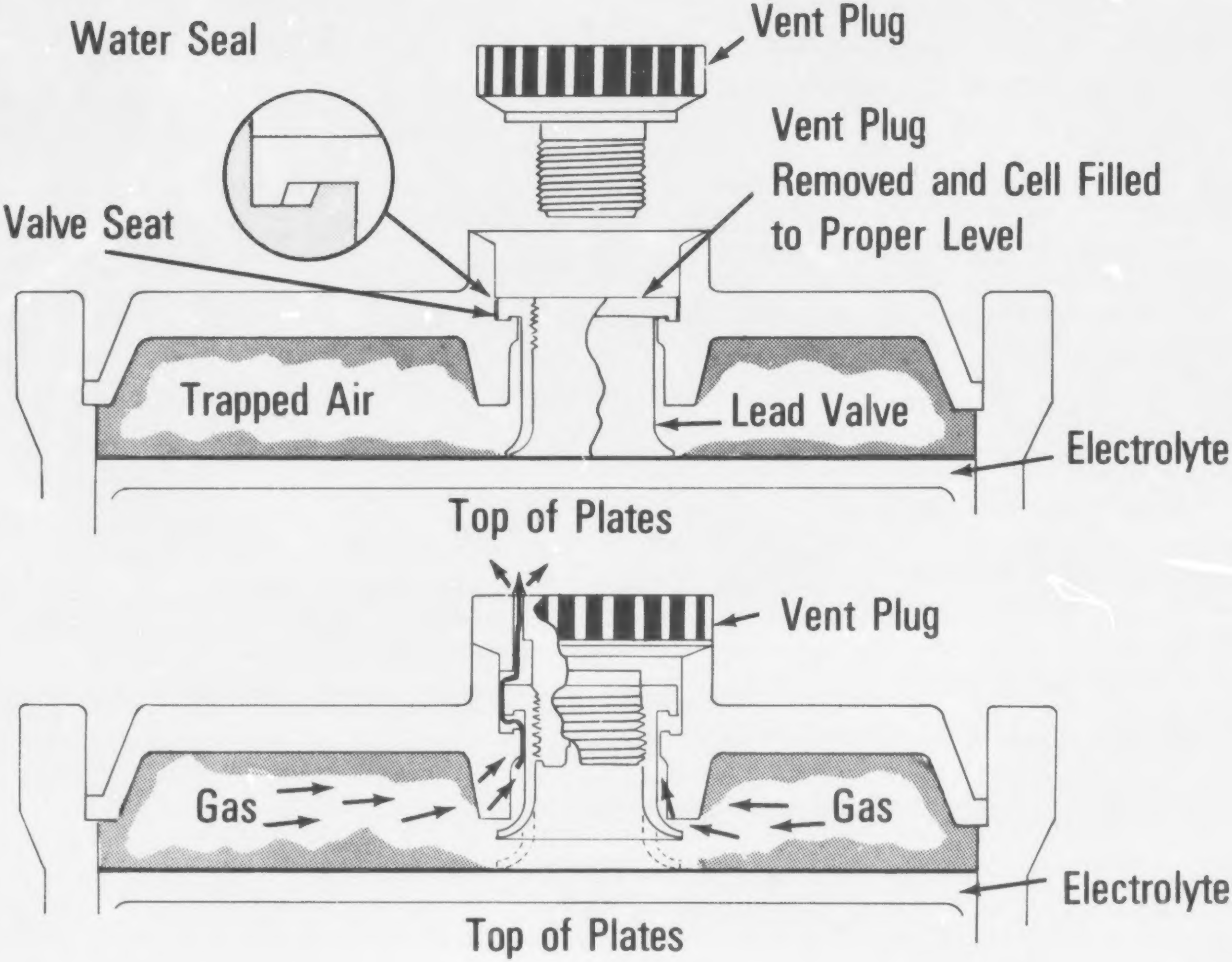
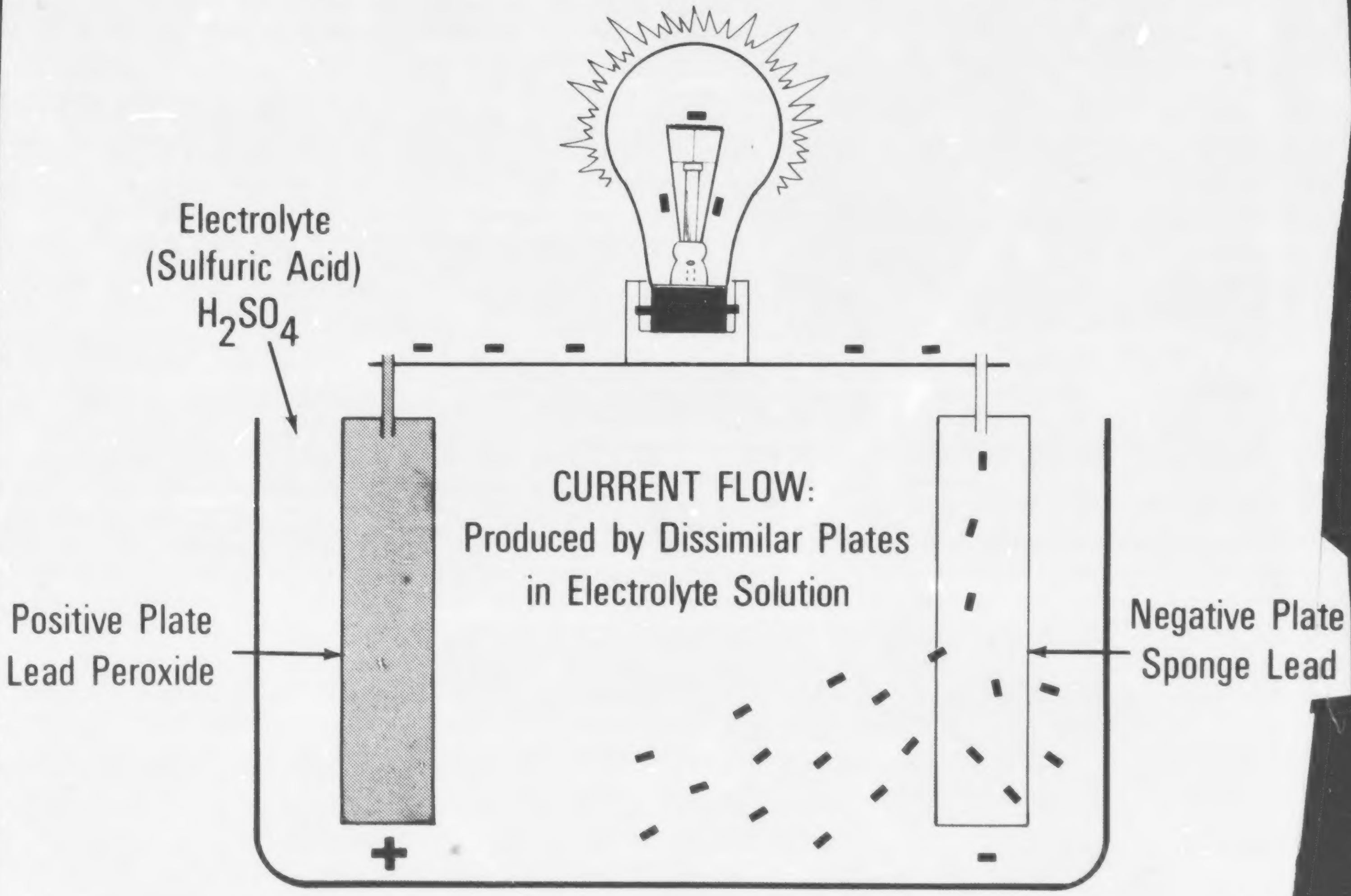


Plate Group

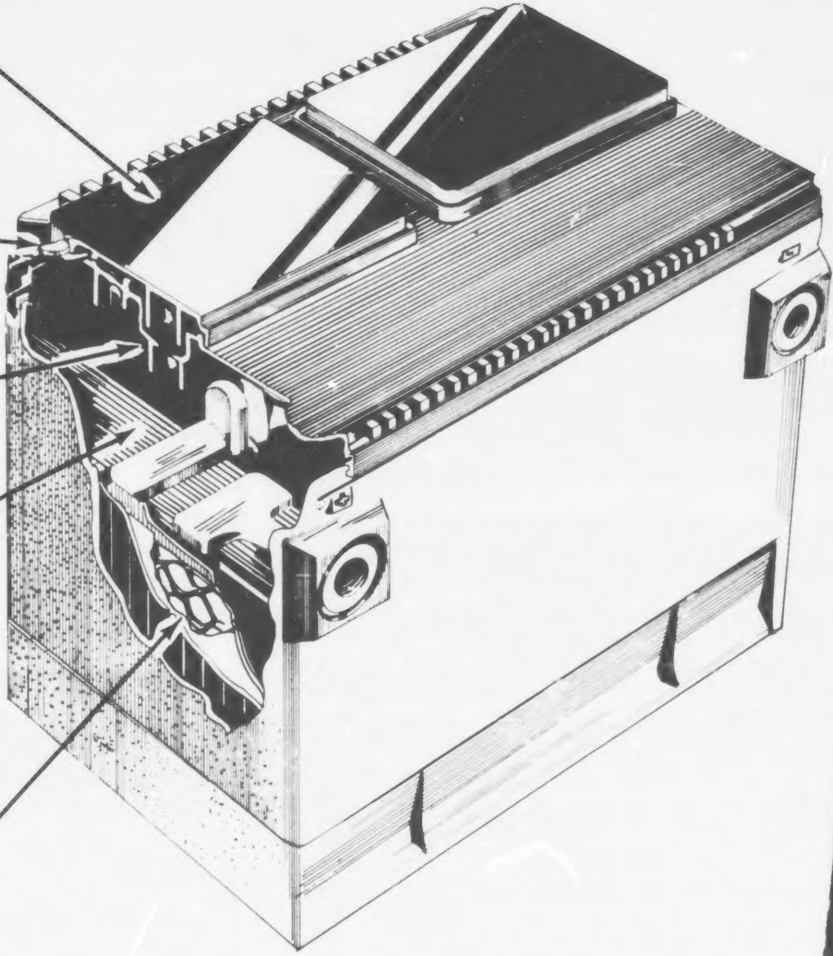
Vent Caps


Water Seal
Vent Plug
Vent Plug
Removed and Cell Filled
to Proper Level
Valve Seat
Trapped Air
Lead Valve
Electrolyte
Top of Plates
Vent Plug
Gas
Gas
Electrolyte
Top of Plates

Converting Chemical Energy to Electrical Energy


Electrolyte
(Sulfuric Acid)
H_2SO_4
CURRENT FLOW:
Produced by Dissimilar Plates
in Electrolyte Solution
Positive Plate
Lead Peroxide
Negative Plate
Sponge Lead
+
-

Service-Free Battery



Heat-Sealed Covers Prevent Electrolyte Contamination and Increase Case Strength

Small Gas Vents Have Built-In Flame Arresters

Special Liquid-Gas Separator Returns Any Liquid to Reservoir

Generous Electrolyte Reservoir Prolongs Battery Life

Wrought Lead-Calcium Grids Are Fine Grained, Strong and Highly Corrosion Resistant

BATTERY SERVICE
UNIT II

JOB SHEET #1--CLEAN AND SERVICE A BATTERY

I. Tools and equipment

A. Full face shield

B. Rubber gloves

C. Rubber apron

D. Bristle brush

E. Wire brush

F. Screwdriver

G. Battery clamp puller

H. Combination end wrenches, 7/16" - 9/16" (11 mm - 15 mm)

I. Baking soda and water solution (two tablespoons of baking soda to one pint of water)

J. Battery anti-corrosion paste

K. Shop towels

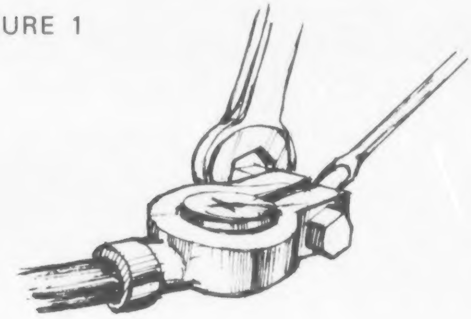
II. Procedure

A. Disconnect battery cables from the battery posts

(NOTE: Always disconnect the grounded battery cable first to avoid short circuits. Use care to avoid twisting the battery cable post.)

1. Pry clamp open (Figure 1)

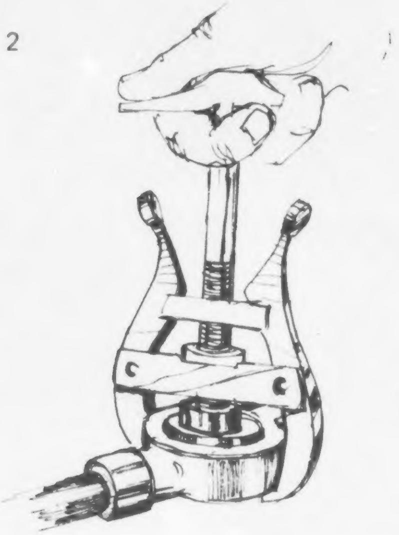
FIGURE 1



JOB SHEET #1

2. Pull cable off (Figure 2)

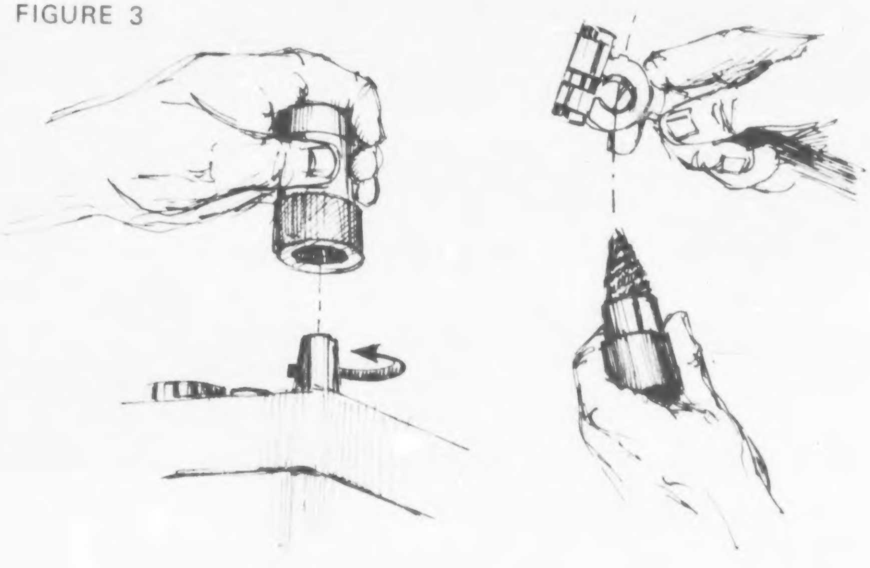
FIGURE 2



B. Clean battery cable clamps and battery post (Figure 3)

(NOTE: Battery posts and inside of battery cable clamps must be clean and bright.)

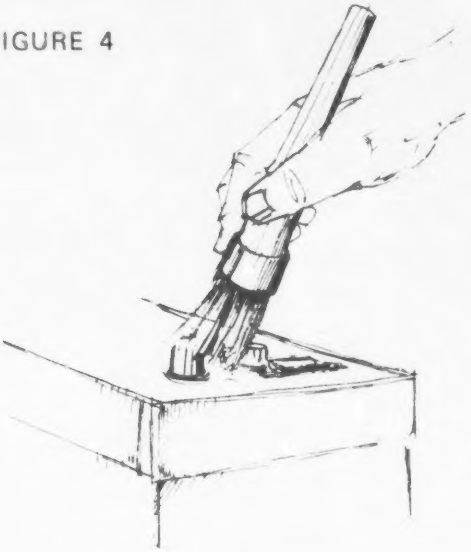
FIGURE 3



JOB SHEET #1

C. Remove loose dirt and corrosion particles from top of battery (Figure 4)

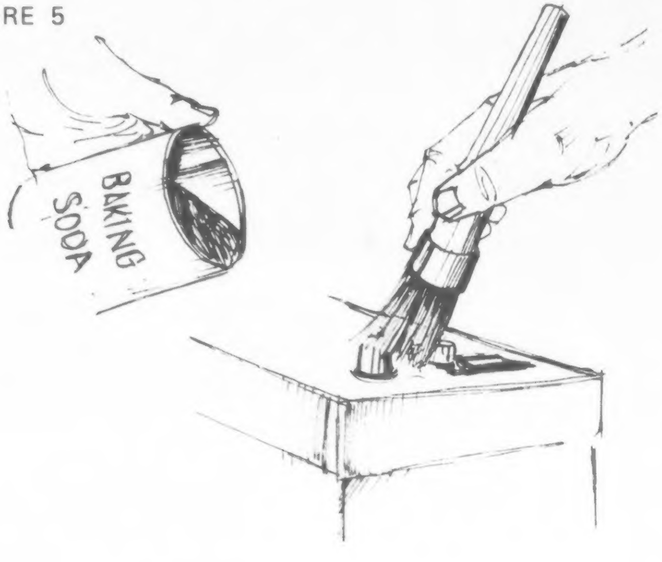
FIGURE 4



D. Brush soda-water solution on battery, battery post, clamps, and battery hold-down (Figure 5)

(NOTE: Keep water and soda from entering the battery through the vent holes in the vent caps.)

FIGURE 5



JOB SHEET #1

E. Wash away residue with clean water (Figure 6)

(NOTE: Remove all residue that may have lodged around battery, frame, or parts of the vehicle.)

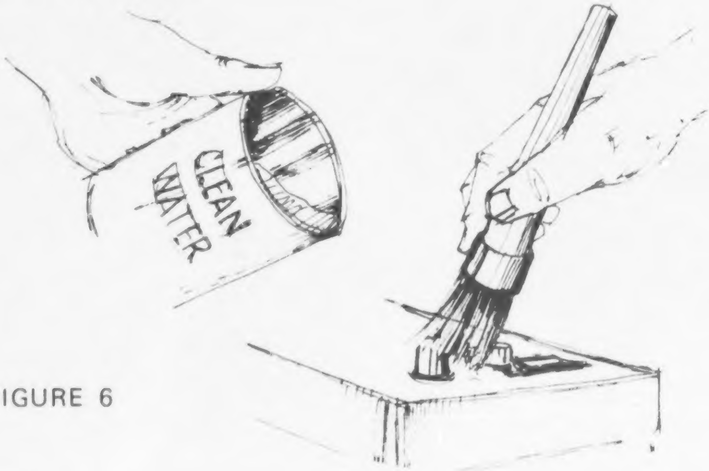


FIGURE 6

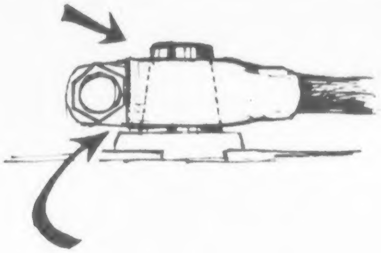
F. Dry the battery and battery cables with a clean cloth

G. Reconnect battery cables to the battery posts (Figure 7)

(CAUTION: Always reconnect the power cable first and the ground cable last.)

FIGURE 7

Battery Post Slightly Above Clamp



H. Spread a coating of battery anti-corrosion paste over the cable clamps and terminals

I. Remove vent caps

J. Check electrolyte level in all cells

K. Add water if necessary to bring electrolyte up to proper level

(NOTE: Do not overfill.)

BATTERY SERVICE
UNIT II

JOB SHEET #2--REMOVE AND REPLACE A BATTERY

I. Tools and equipment

   A. Full face shield

   B. Protective clothing

   C. Wire brush

   D. Screwdriver

   E. Battery clamp puller

   F. Combination end wrenches, 7/16" - 9/16" (11 mm - 15 mm)

   G. Battery cable spreader

   H. Battery post and cable cleaner

   I. Battery lift strap

II. Procedure

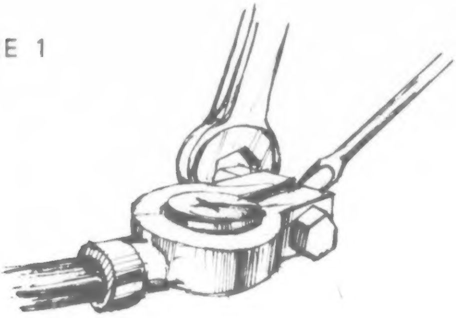
   (NOTE: Observe the location of the positive post so the battery can be installed in the same way.)

   A. Disconnect the battery cables from the battery posts

      (NOTE: Always disconnect the grounded battery cable first to avoid short circuits. Use care to avoid twisting the battery cable post.)

      1. Pry clamp open (Figure 1)

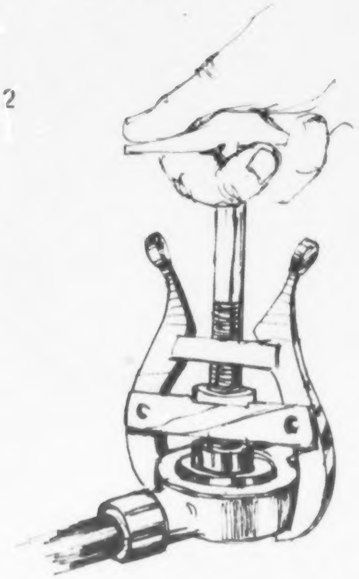
FIGURE 1



JOB SHEET #2

2. Pull cable off (Figure 2)

FIGURE 2



B. Remove the battery hold-down

C. Remove the battery from the carrier

(NOTE: Use a suitable battery lift strap to lift the battery.)

D. Inspect the battery carrier for dirt or corrosion

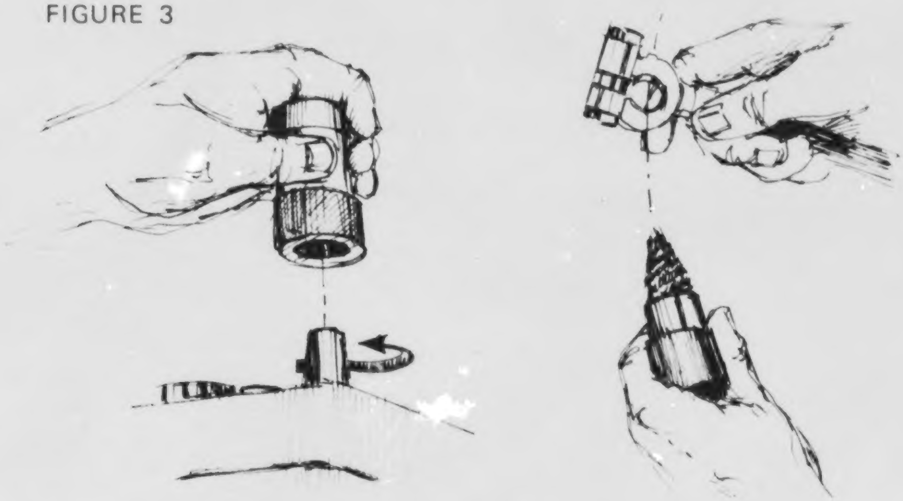
(NOTE: Clean with baking soda and water as required.)

E. Check battery cables for worn or frayed insulation

JOB SHEET #2

F. Clean the inside of battery cables clean and bright (Figure 3)

FIGURE 3



G. Set the battery into place using a lift strap

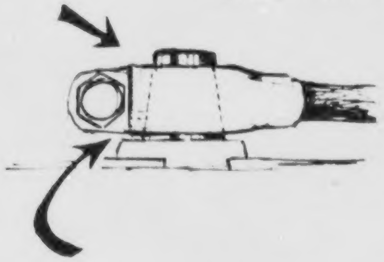
(NOTE: Position the battery to allow for correct battery cable attachment.)

H. Install the battery hold-down clamp or strap and tighten securely

I. Reconnect battery cables to the battery posts (Figure 4)

(NOTE: Always reconnect the power cable first and the ground cable last.)

FIGURE 4



Battery Post Slightly Above Clamp

J. Tighten the battery cable clamps securely

(NOTE: Use care to avoid twisting the battery cable post.)

K. Spread a coating of battery anti-corrosion paste over the cable clamps and terminals

BATTERY SERVICE
UNIT II

JOB SHEET #3-MEASURE BATTERY ELECTROLYTE WITH A HYDROMETER

I. Tools and equipment

   A. Hydrometer

   B. Shop towels

   C. Container of clean water

II. Procedure

   A. Remove vent caps from battery

   B. Insert the hydrometer into the first cell

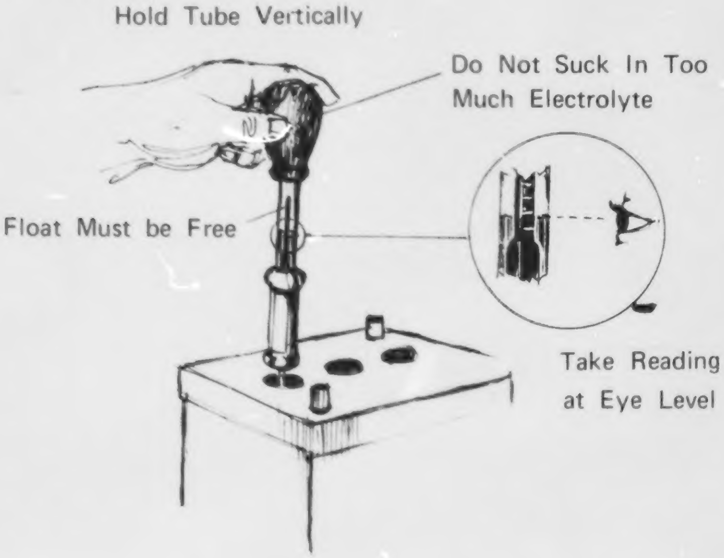
   C. Squeeze the rubber bulb to draw electrolyte into the hydrometer to suspend the float

   (NOTE: If the electrolyte level is too low, add water until electrolyte level is correct, charge for one hour, and recheck.)

   D. Take reading at eye level (Figure 1)

   (NOTE: Make sure the float is not bumping the top of the hydrometer tube or sticking to the side of the tube. Write down reading for each cell.)

FIGURE 1


Hold Tube Vertically
Do Not Suck In Too Much Electrolyte
Float Must be Free
Take Reading at Eye Level

JOB SHEET #3

E. Squeeze bulb to return electrolyte to cell

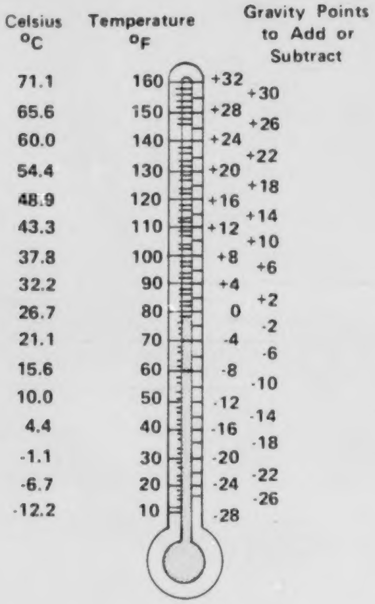
F. Repeat for other cells

G. Adjust the readings for temperature (Figure 2)

1. Add four gravity points (0.004) to the reading for each 10°F (5.5°C) above 80° (26.7°C)

2. Subtract four gravity points (0.004) for each 10°F (5.5°C) below 80°F (26.7°C)

FIGURE 2



Temperature Adjustment Chart

(NOTE: Specific gravity should read from 1.215 to 1.270, corrected for 80°F (26.7°C) electrolyte temperature. The variation in readings between cells should be no more than 0.050. If the readings are not within this range, further testing will be required.)

H. Replace vent caps upon completion of test

I. Flush any spilled electrolyte with clean water

BATTERY SERVICE
UNIT II

JOB SHEET #4--LOAD TEST A BATTERY

I. Tools and equipment

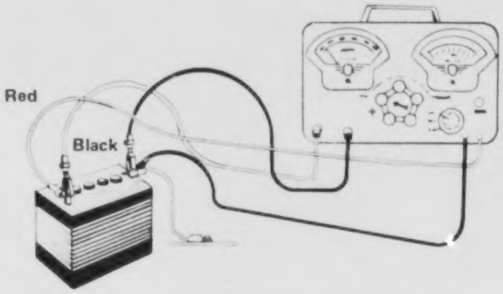
   A. Battery capacity tester

   B. Appropriate conductors

II. Procedure

   A. Connect tester (Figure 1)

FIGURE 1



Battery Capacity Test

   B. Tighten rheostat knob to apply a load to the battery

   (CAUTION: Do not apply the load to the battery for more than 15 seconds at a time.)

   C. Apply load equal to three times the ampere-hour rating of battery being tested

   (NOTE: Ampere-hour rating may be marked on the outside of the battery case. If not, consult manufacturer's specifications for the vehicle's requirements.)

   D. Read battery voltage at the end of 15 seconds

   (NOTE: If voltage drops below 9.6 volts in 15 seconds, proceed to the 3-minute charge test. See Job Sheet #5.)

   E. Loosen rheostat to relieve load at end of 15 seconds

   F. Disconnect tester

BATTERY SERVICE
UNIT II

JOB SHEET #5--CHARGE TEST A BATTERY FOR THREE MINUTES

I. Tools and equipment

A. Adjustable, fast-rate battery charger

B. Battery capacity tester

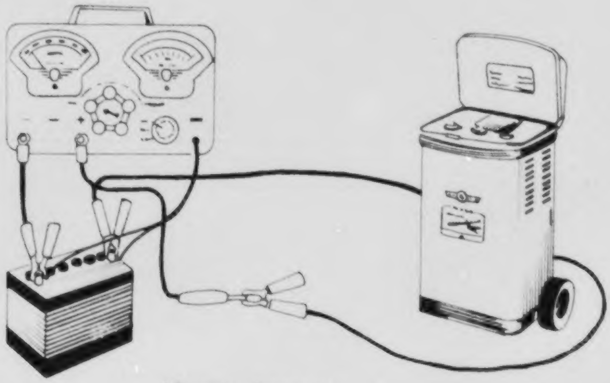
C. Appropriate conductors

II. Procedure

(NOTE: This test cannot be performed on service-free batteries because the individual cells cannot be checked.)

A. Connect tester and charger (Figure 1)

FIGURE 1



12-volt Battery

B. Turn charger on and adjust the charging rate to 40 amperes

C. Charge battery for 3 minutes

D. Read individual cell voltages with battery still in operation

(NOTE: If they vary by more than 0.1 volt, replace the battery.)

E. Read total battery voltage

(NOTE: If it is over 15.5 volts, the battery is unsatisfactory and must be given a long slow charge and load tested again. If voltage under load test is less than 9.6 volts, replace battery.)

BATTERY SERVICE
UNIT II

TEST

NAME____________________________________ SCORE____________________

1. Match the terms on the right to the correct definitions.

______a. Two or more connected cells which convert chemical energy into electrical energy

______b. One positive plate group and one negative plate group

______c. Similar plates welded to a plate strap

______d. Solution of water and sulfuric acid, usually at a ratio of 60% to 40% respectively

______e. Weight of liquid compared to an equal volume of distilled water

______f. Glass barrel syringe containing a calibrated float used to measure specific gravity

______g. Metals not alike in substance or essentials

______h. Oxidation of positive plate grid wires and formation of lead sulfate crystals on the lead peroxide material

______i. Capacity rated according to the quantity of electricity that can be taken from a fully charged battery over a definite period of time

1. Electrolyte
2. Hydrometer
3. Specific gravity
4. Dissimilar metals
5. Battery
6. Plate group
7. Sulfated
8. Cell
9. Battery rating

2. List three functions of the battery.

a. ____

b. ____

c. ____

3. Match the battery parts on the right to the correct purposes.

_____a. Stores active material which brings about a chemical reaction to provide electricity

_____b. Insulates the negative plate from the positive plate

_____c. Provides a low resistance connection for the battery cable

_____d. Holds the cells and electrolyte to make up the completed battery

_____e. Closes the opening in each cell cover and provides a vent to allow gases to escape

_____f. Connects cells in series

_____g. Connects plate group to terminal post

1. Terminal post
2. Battery case
3. Plate
4. Separator
5. Cell connector
6. Vent cap
7. Post plate strap

4. Select from the following list the processes by which a battery converts chemical energy into electrical energy. Place an "X" in the correct blanks.

_____a. Two dissimilar metals placed in acid solution will produce chemical action

_____b. The more active metal will accumulate electrons and become positively charged

_____c. The more active metal will lose electrons and become positively charged

_____d. The less active metal will accumulate electrons and become negatively charged

_____e. The less active metal will lose electrons and become negatively charged

5. List factors affecting battery voltage and capacity.

a. Battery voltage

1) ______________________________

2) ______________________________

b. Battery capacity (in amperes)

1) ______________________________

2) ______________________________

3) ______________________________

6. Match the types of battery ratings on the right to the correct descriptions.

_____a. Length of time in minutes that a fully charged battery at 80°F (26.7°C) can deliver a specific quantity of current	1. Ampere-hour rating (reserve capacity rating)
_____b. Measure of the battery's cold cranking ability determined by multiplying the maximum current by the maximum voltage the battery is capable of producing	2. Cold cranking rating
	3. Peak watt rating (PWR)
_____c. Number of amperes that a battery can deliver for 30 seconds at 0°F (-17.8°C) without the cell voltage dropping below 1.2 volts	

7. Select from the list below the safety rules to be observed during the care and maintenance of batteries by placing an "X" in the correct blanks.

_____a. Do not allow battery electrolyte to come in contact with clothing, skin, eyes, or painted surfaces

_____b. Keep flames or sparks away from battery because gases given off by the battery are very explosive

_____c. Wear safety goggles, rubber gloves, and rubber apron when servicing batteries

_____d. Place hands under both ends of battery when removing

_____e. Flush immediately with water any area of skin which acid has contacted

_____f. Avoid breathing fumes from a battery that is being charged

8. Describe three features of a service-free battery.

a.____

b.____

c.____

9. Demonstrate the ability to:

a. Clean and service a battery.

b. Remove and replace a battery.

c. Measure battery electrolyte with a hydrometer.

d. Load test a battery.

e. Charge test a battery for three minutes.

(NOTE: If these activities have not been accomplished prior to the test, ask the instructor when they should be completed.)

BATTERY SERVICE
UNIT II

ANSWERS TO TEST

1. a. 5
   b. 8
   c. 6
   d. 1
   e. 3
   f. 2
   g. 4
   h. 7
   i. 9

2. a. To supply current for cranking the engine
   b. To supply current when the demand exceeds the output of the charging system
   c. To stabilize the voltage in the system during operation

3. a. 3
   b. 4
   c. 1
   d. 2
   e. 6
   f. 5
   g. 7

4. a, c, d

5. a. Battery voltage
      1) All cells contain only two volts
      2) Battery voltage can be changed by adding or subtracting cells that are connected in series
   b. Battery capacity (in amperes)
      1) The number of plates
      2) The area of plate material
      3) The strength of the electrolyte

6. a. 1
   b. 3
   c. 2

7. a, b, c, e, f

8. a. Case sealed with lifetime supply of electrolyte
   b. Special liquid-gas separator which returns liquid to reservoir
   c. Special plate material which drastically reduces
      1) Water loss from the charging process
      2) Self-discharge while battery is not in use
      3) Overcharge when used in high temperatures
9. Performance skills evaluated to the satisfaction of the instructor

STARTING SYSTEM
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to state the purpose of the starting system, identify the starting system components, and discuss the magnetic and operating principles of a starter. The student should be able to demonstrate the ability to perform starting system tests and bench tests and repair a starter. This knowledge will be evidenced through demonstration and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with the starting system to the correct definitions.
2. State the purpose of the starting system.
3. Describe the operating principle of the starter.
4. Discuss the magnetic principles of the starter.
5. Describe the current flow in a series wound starter.
6. List the components of the starting system.
7. Name the types of starter switches.
8. Identify the parts of a starter.
9. Identify the major parts of a gear reduction starter.
10. Identify the types of starter drives.
11. Identify the components of a starter control circuit.
12. Match starting system control circuit components to their functions.
13. Demonstrate the ability to:
    a. Load test a starter.
    b. Test starter circuit resistance.
    c. Test starter control circuit resistance.

d. Remove and replace a starter.

e. Disassemble, check, and reassemble a starter.

f. Disassemble and reassemble a gear reduction starter.

STARTING SYSTEM
UNIT III

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss procedures outlined in the job sheets.

   G. Give test.

II. Unit references:

A. *Electrical Systems.* Fundamentals of Service Series. Moline, Illinois: Deere and Co., 1972.

B. Billiet, Walter E., and Goings, Leslie F. *Automotive Electrical Systems.* 3d ed. Chicago: American Technical Society, 1970.

C. Crouse, William H. *Automotive Mechanics.* 7th ed. New York: McGraw-Hill Book Co./Webster Div., 1975.

D. *Chevrolet Chassis Overhaul Manual.* Detroit, Michigan: Chevrolet Motor Div./General Motors Corp., 1974.

E. *Chrysler, Plymouth, Dodge Electrical Service Manual.* Detroit: Chrysler Corp., 1976.

F. Crouse, William H. *Automotive Electrical Equipment.* 8th ed. New York: McGraw-Hill Book Co., 1976.

G. *Ford Electrical Car Shop Manual.* Dearborn, Michigan: Ford Motor Co., 1975-76.

STARTING SYSTEM
UNIT III

INFORMATION SHEET

I. Terms and definitions

   A. Armature--Series of loops of wire arranged around a shaft and made to rotate due to magnetic reaction

   B. Brush--Sliding contact used to pass electrical current to a rotating armature

   C. Commutator--Device for reversing the direction of current flowing through the conductors of the rotating armature in a motor

   D. Field coil--Coil or winding in a generator or starter which produces a magnetic field as current passes through it

   E. Pole shoe--Solid or laminated metal core inside a field coil used to concentrate the magnetic lines of force to produce a strong magnet

   F. Solenoid--Tubular field coil with a movable metal core used to engage the starter drive with the flywheel and to close the starter switch

   G. Frame--Housing for starter and mounting for field coils and pole shoes

   H. Starter drive--Device used to transmit power produced in starter to automobile engine

   I. Gear reduction starter--Starter which contains a set of gears that reduces its cranking speed and increases the torque

II. Purpose of the starting system--To convert electrical energy from the battery into mechanical energy at the starter to crank the engine

III. Operating principle of the starter--The small electric motor with heavy windings of very low resistance carries a high amperage current (150 to 250 amps) at a low voltage for a short period of time

IV. Magnetic principles of the starter (Transparencies 1 and 2)

   A. Like magnetic fields repel and opposite magnetic fields attract each other

   B. Current flow in a conductor creates a magnetic field around the conductor

   C. Stationary field between poles of magnet interacts with magnetic field around conductor

INFORMATION SHEET

D. Lines of force oppose each other on one side of conductor and reinforce each other on the other side

V. Path of current flow in a series wound starter (Transparency 3)

A. High amperage current flows from battery to starter through heavy battery cable

B. Current enters motor at large cable terminal and travels through field coils

C. Field coils are connected to insulated brushes which pass current to armature

D. Current passes through armature windings and back to grounded brushes

E. Grounded brushes return current to ground and back to battery

VI. Components of the starting system (Transparency 4)

A. Battery

(NOTE: The battery is the source of electrical power.)

B. Key switch

(NOTE: The key switch activates the starter switch.)

C. Starter switch

(NOTE: The starter switch closes the heavy circuit from battery to starter.)

D. Starter

(NOTE: The starter drives the flywheel to crank the engine.)

E. Small gauge switch wire

(NOTE: The wire carries a low amount of current to energize the starter switch.)

F. Battery cables

(NOTE: The cables carry large amounts of current to operate the starter.)

VII. Types of starter switches (Transparency 5)

A. Solenoid

B. Magnetic

INFORMATION SHEET

VIII. Parts of the starter (Transparency 6)

- A. Through bolt
- B. End frame
- C. Starter brush
- D. Starter frame
- E. Armature
- F. Starter drive
- G. Drive housing
- H. Shift lever
- I. Solenoid
- J. Bushing
- K. Field coil
- L. Commutator
- M. Pole shoe

IX. Major parts of the gear reduction starter (Transparency 7)

- A. End frame
- B. Starter frame
- C. Armature
- D. Brush and spring
- E. Brush plate
- F. Gear and solenoid housing
- G. Solenoid assembly
- H. Solenoid moving core

INFORMATION SHEET

- I. Shifter fork
- J. Clutch drive
- K. Reduction gearset
- L. Starter field
- M. Pinion shaft

X. Types of starter drives (Transparency 8)

- A. Overrunning clutch
- B. Folo-thru bendix

XI. Components of a starter control circuit (Transparencies 9 and 10)

- A. Ignition switch

  (NOTE: The ignition switch may be located on the dash panel or on the steering column.)

- B. Neutral-start switch

  (NOTE: In automatic transmissions, the neutral-start switch may be located on the transmission or on the steering column. A manual transmission may have a clutch-start switch located on the clutch linkage.)

- C. Seat-belt starter interlock system
- D. Starter relay
- E. Magnetic switch
- F. Solenoid

XII. Starting system control circuit components and their functions (Transparencies 9 and 10)

- A. Ignition switch--Initiates the control circuit current
- B. Neutral-start switch--Opens the control circuit when the automatic transmission selector lever is not in neutral or park
- C. Seat-belt starter interlock system--Opens the starter control circuit unless the passengers in the front seat connect their seat belts

  (NOTE: The federal government has eliminated the regulation requiring manufacturers to install this system. It is now legal for the system to be deactivated on cars now in operation.)

INFORMATION SHEET

D. Starter relay--Connects the starter solenoid to the battery when its contacts are closed

(NOTE: The starter relay enables the safety components of the control circuit to operate on very low current flow yet provides the starter solenoid with a much higher operating current.)

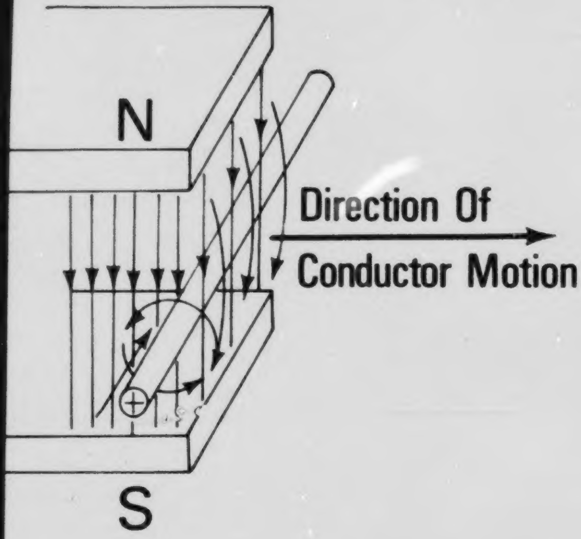
E. Starter solenoid--Shifts the starter drive gear in mesh with the flywheel and then closes the heavy contact switch between the battery and starter

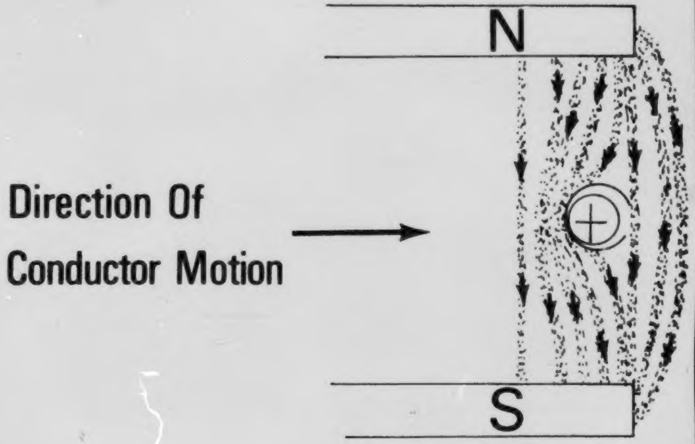
(NOTE: The sliding pole shoe starter has a solenoid action. As the pole shoe moves, it shifts the starter drive gear in mesh with the flywheel. The electrical circuit is controlled by a magnetic switch.)

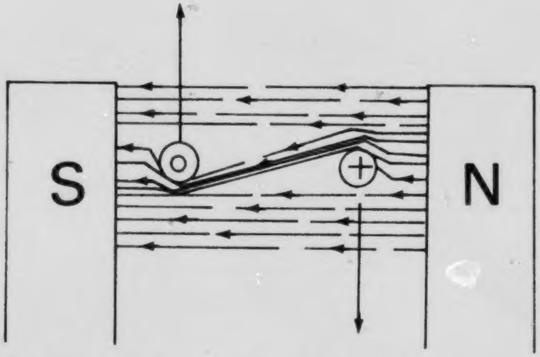
F. Magnetic starter switch--Closes circuit between the battery and starter

(NOTE: Starting systems with a magnetic starter switch use either a folo-thru bendix or a sliding field with overrunning clutch type starter drive units.)

Magnetic Principles Of The Starter


N
S
Direction Of
Conductor Motion

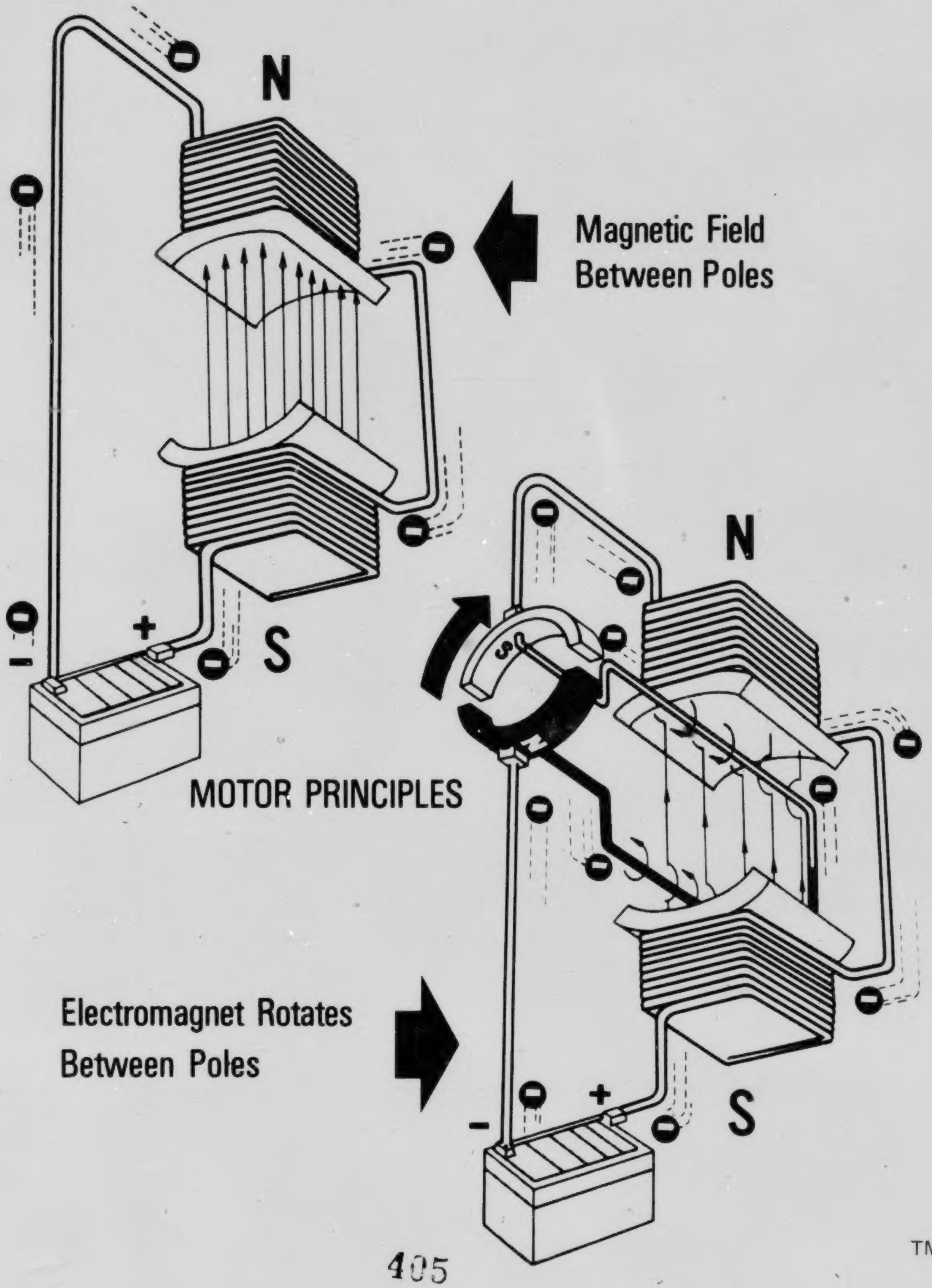

Direction Of
Conductor Motion
N
S



Direction of Magnetic Field and Conductor Movement

Magnetic Principles Of The Starter

(Continued)

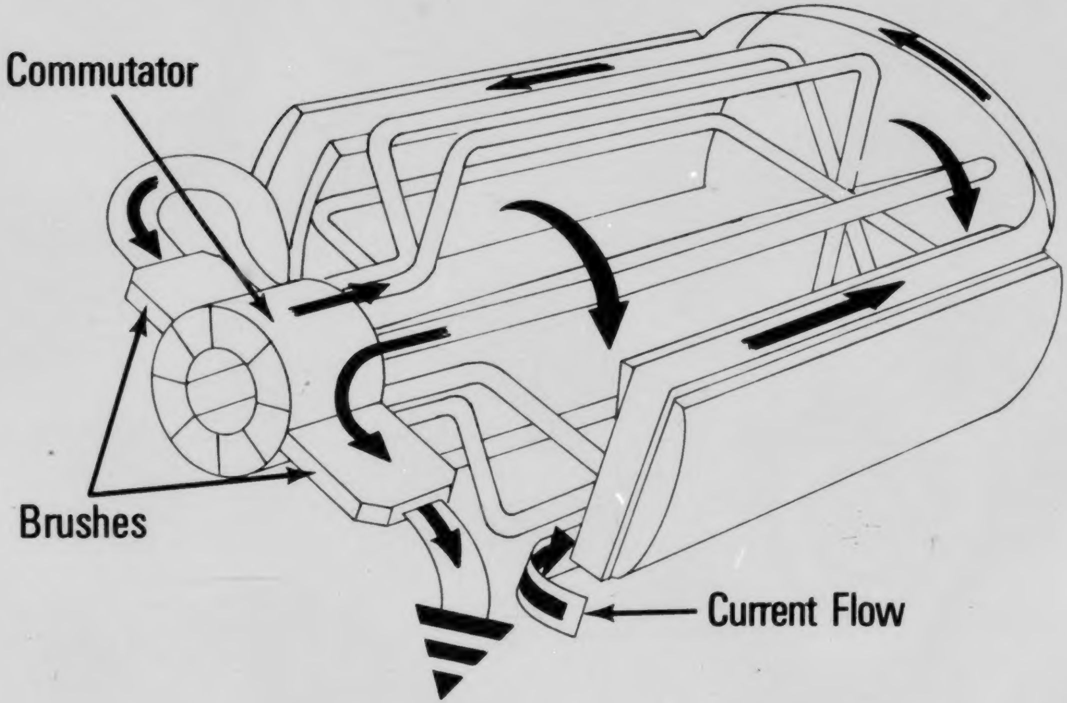


Magnetic Field
Between Poles

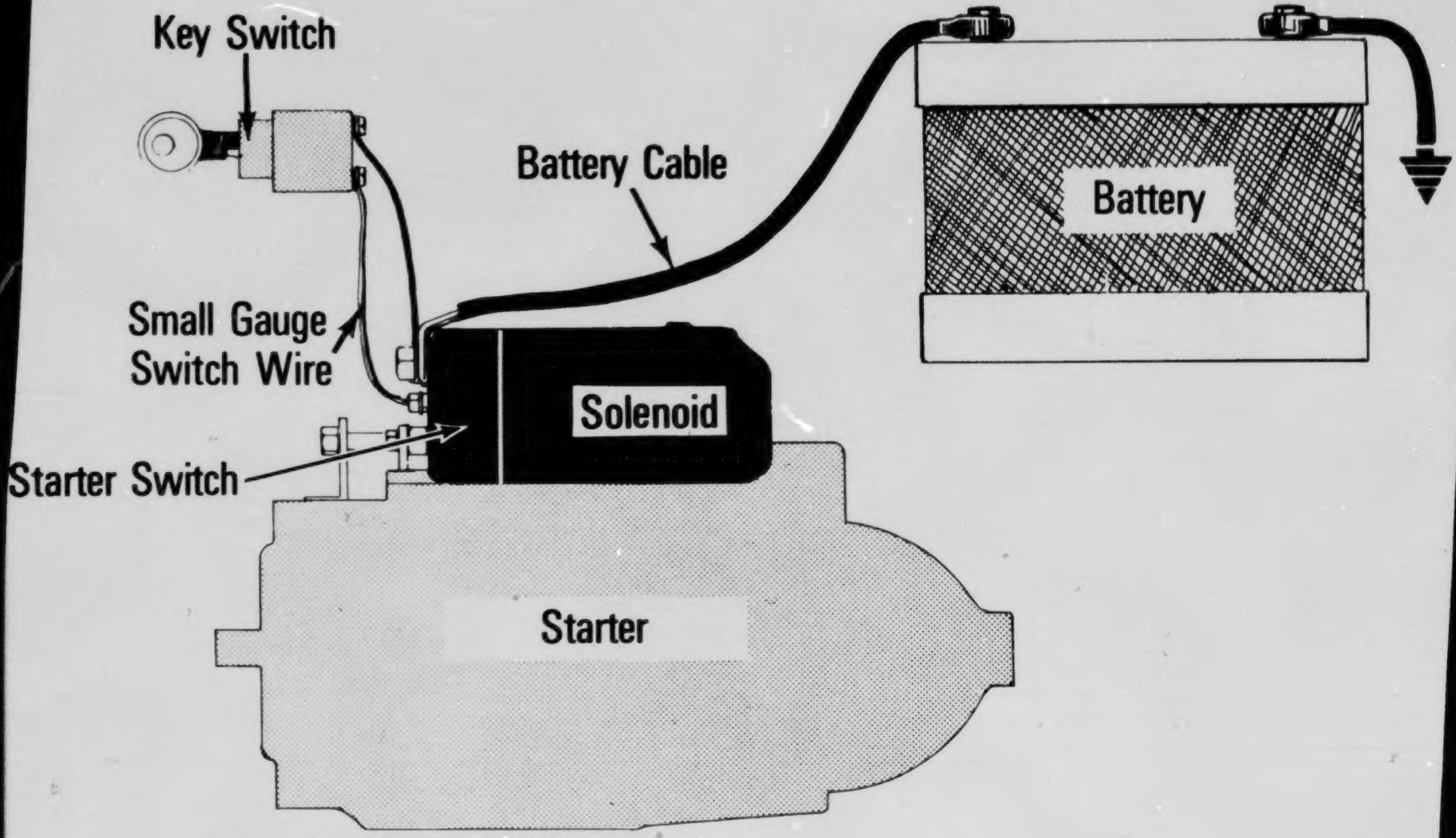
MOTOR PRINCIPLES

Electromagnet Rotates
Between Poles

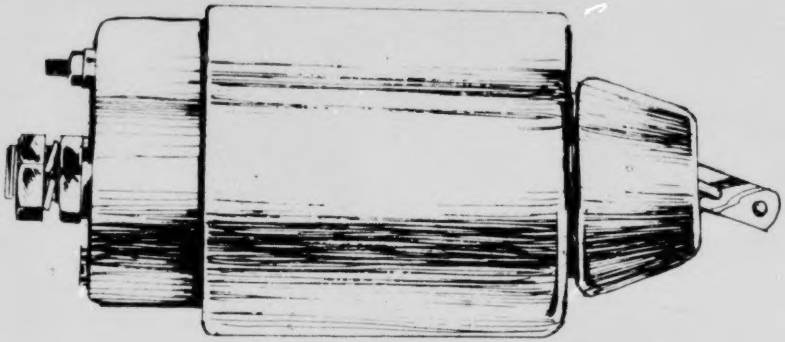
Current Flow In Series Wound Starter


Commutator
Brushes
Current Flow

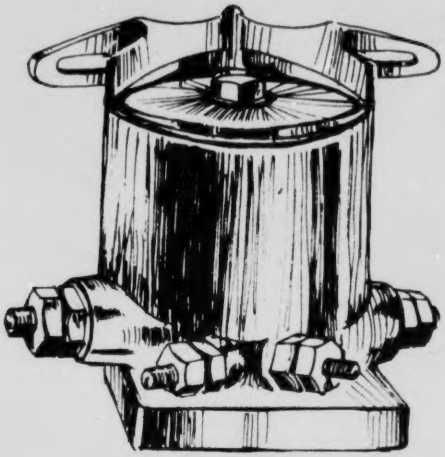
Components Of The Starting System


Key Switch
Battery Cable
Battery
Small Gauge Switch Wire
Solenoid
Starter Switch
Starter

Types Of Starter Switches

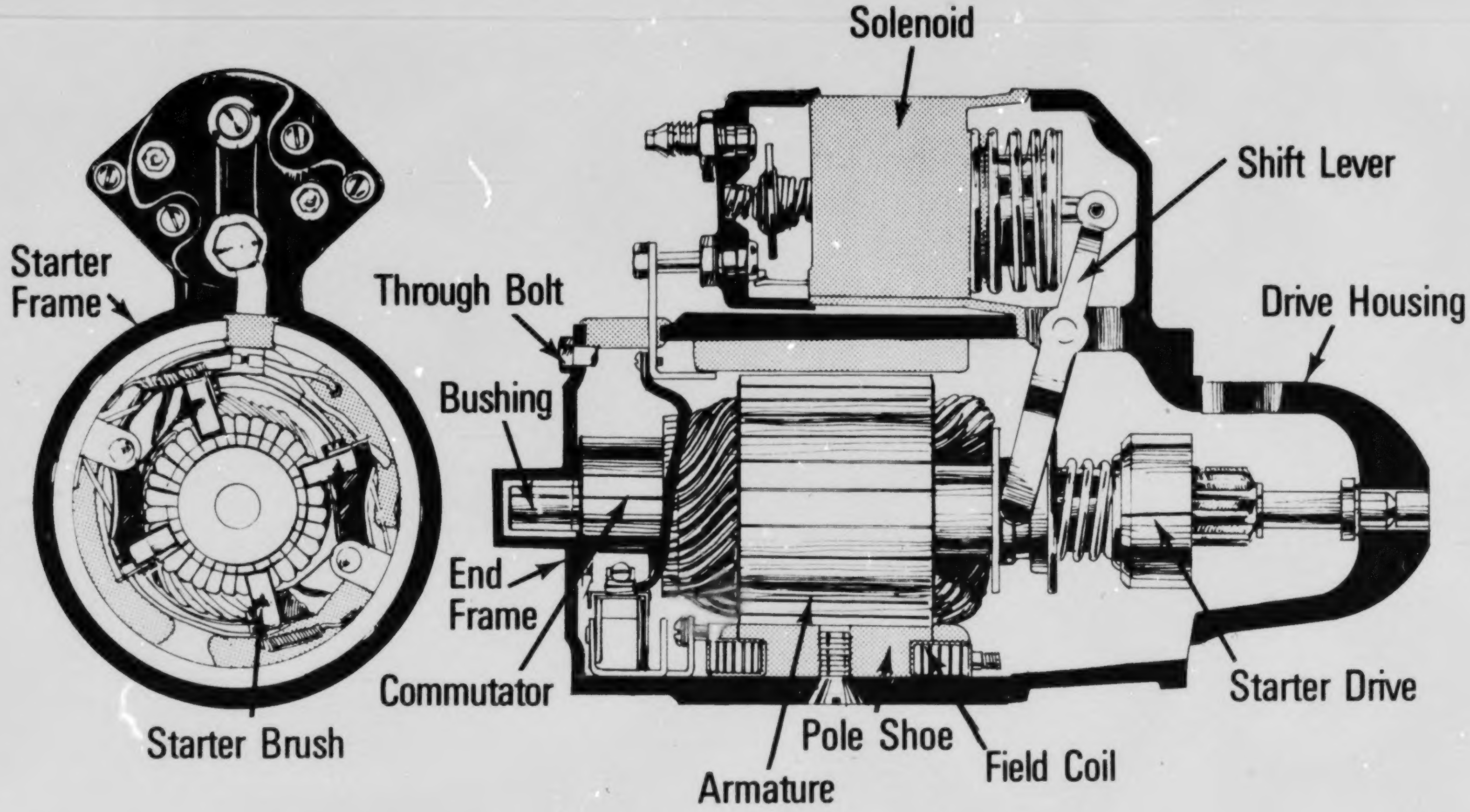


Solenoid

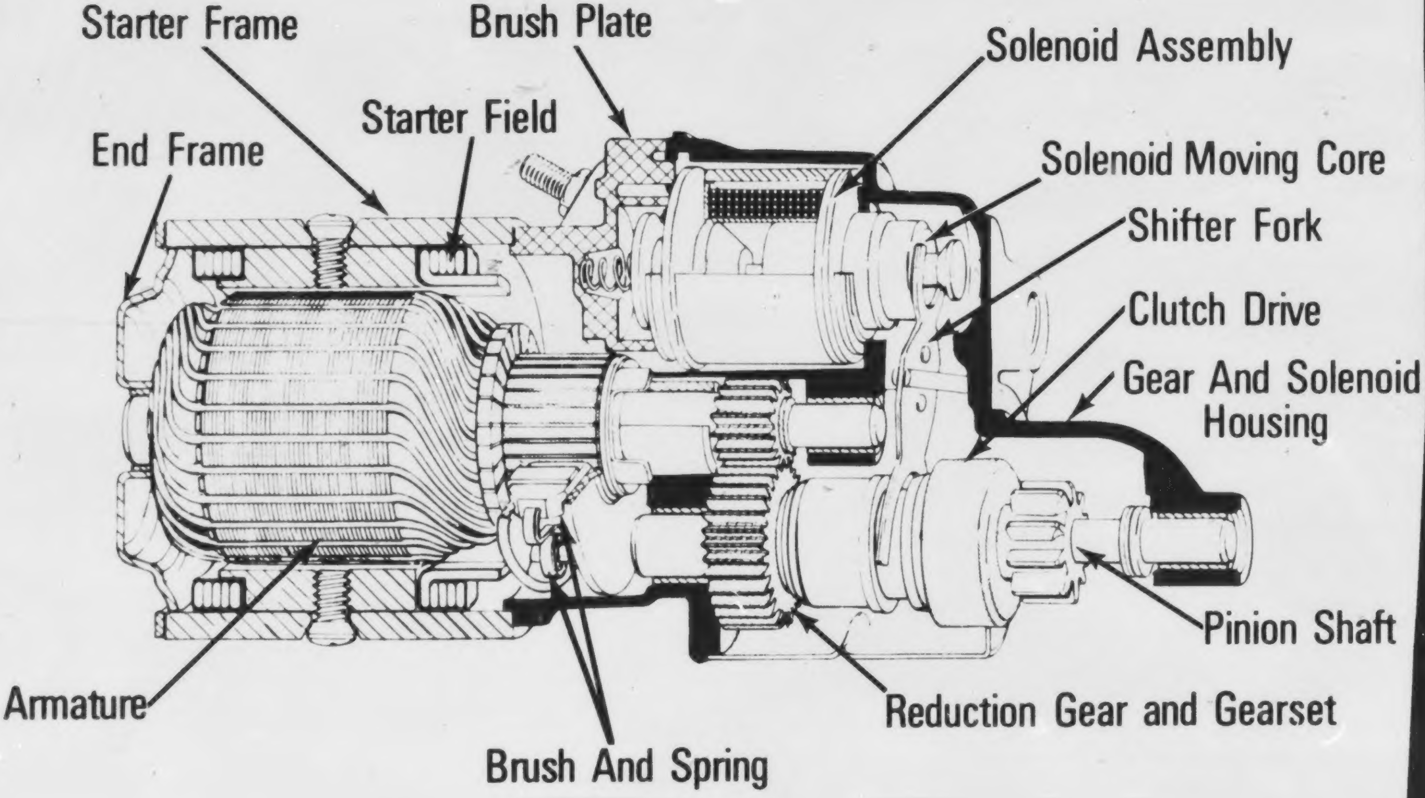


Magnetic

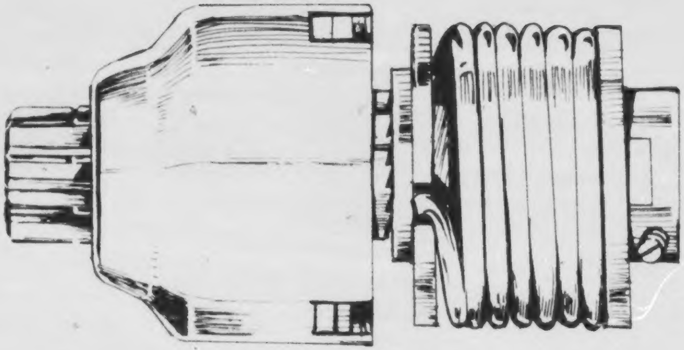
Parts Of The Starter


Solenoid
Shift Lever
Starter Frame
Through Bolt
Drive Housing
Bushing
End Frame
Commutator
Starter Drive
Starter Brush
Pole Shoe
Field Coil
Armature

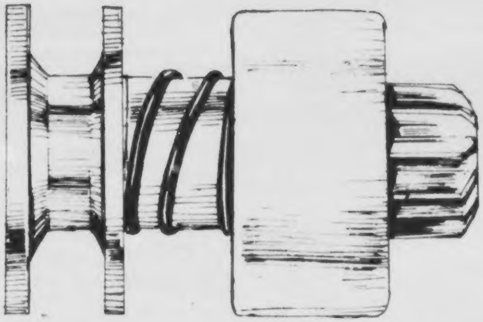
Major Parts Of The Gear Reduction Starter


Starter Frame
Brush Plate
Solenoid Assembly
Starter Field
End Frame
Solenoid Moving Core
Shifter Fork
Clutch Drive
Gear And Solenoid Housing
Pinion Shaft
Armature
Reduction Gear and Gearset
Brush And Spring

Types Of Starter Drives

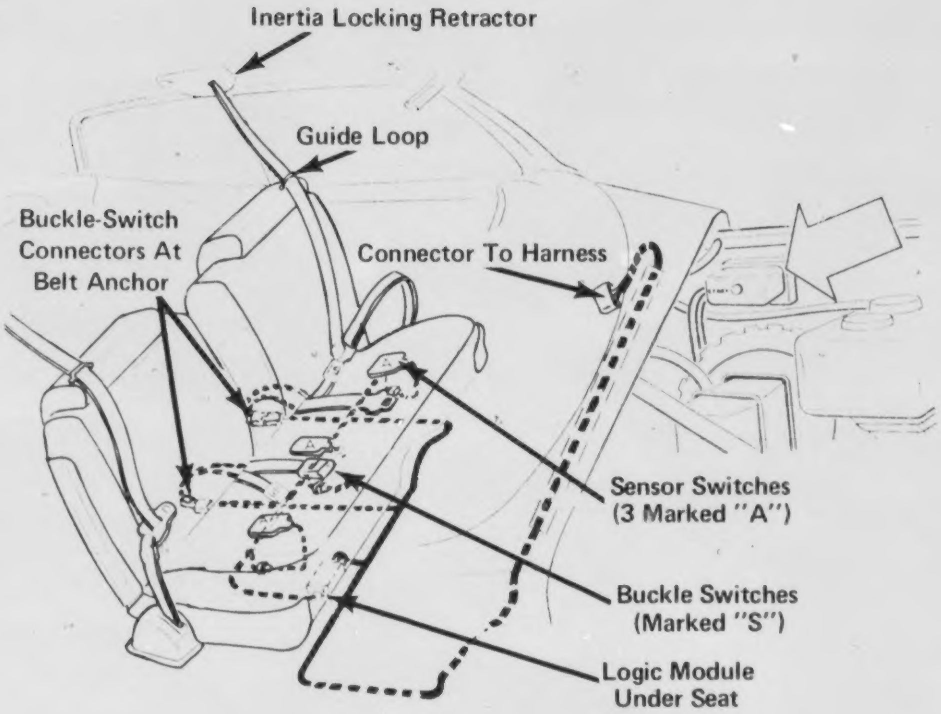


Folo-Thru Bendix

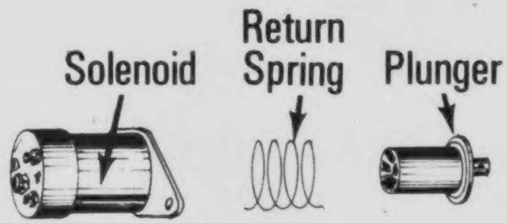


Overrunning Clutch

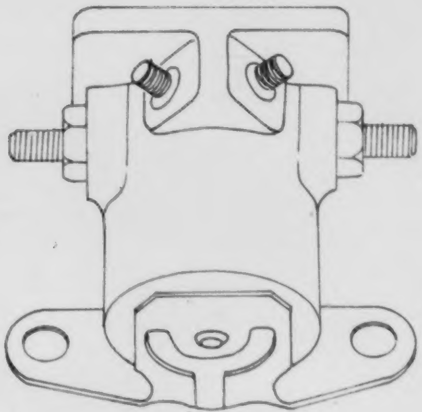
Starter Control Circuit Components


Inertia Locking Retractor
Guide Loop
Buckle-Switch Connectors At Belt Anchor
Connector To Harness
Sensor Switches (3 Marked "A")
Buckle Switches (Marked "S")
Logic Module Under Seat

Seat Belt Starter Interlock System


Solenoid
Return Spring
Plunger

Solenoid

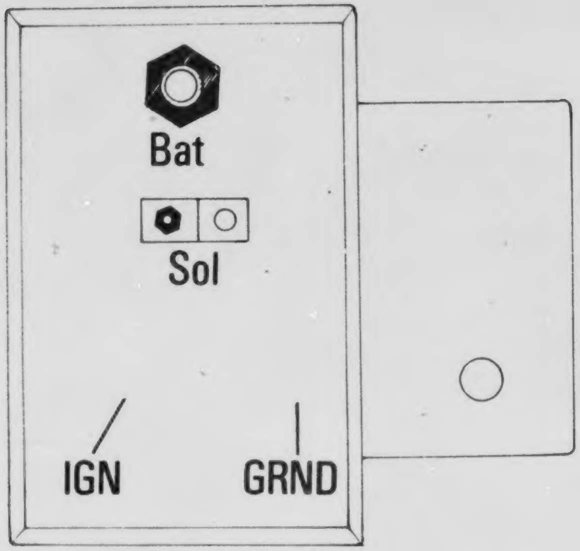


Magnetic Switch

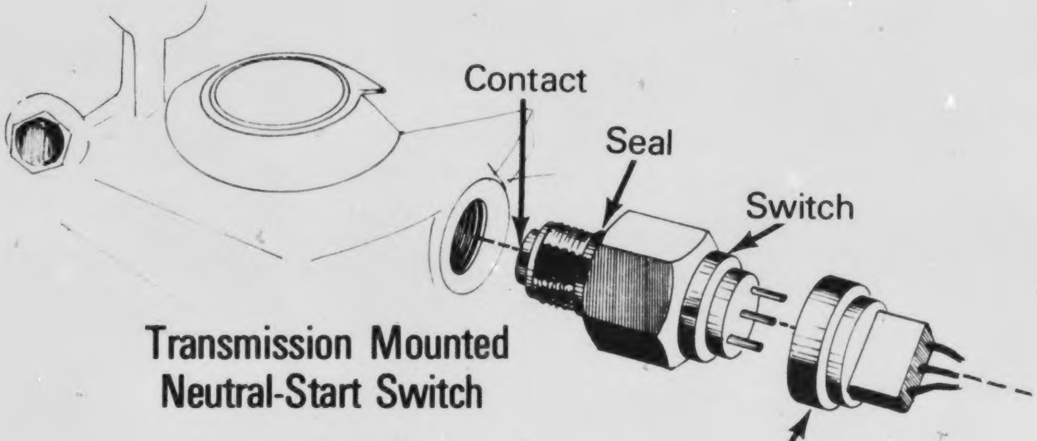
TM 9

AM II - 121-B

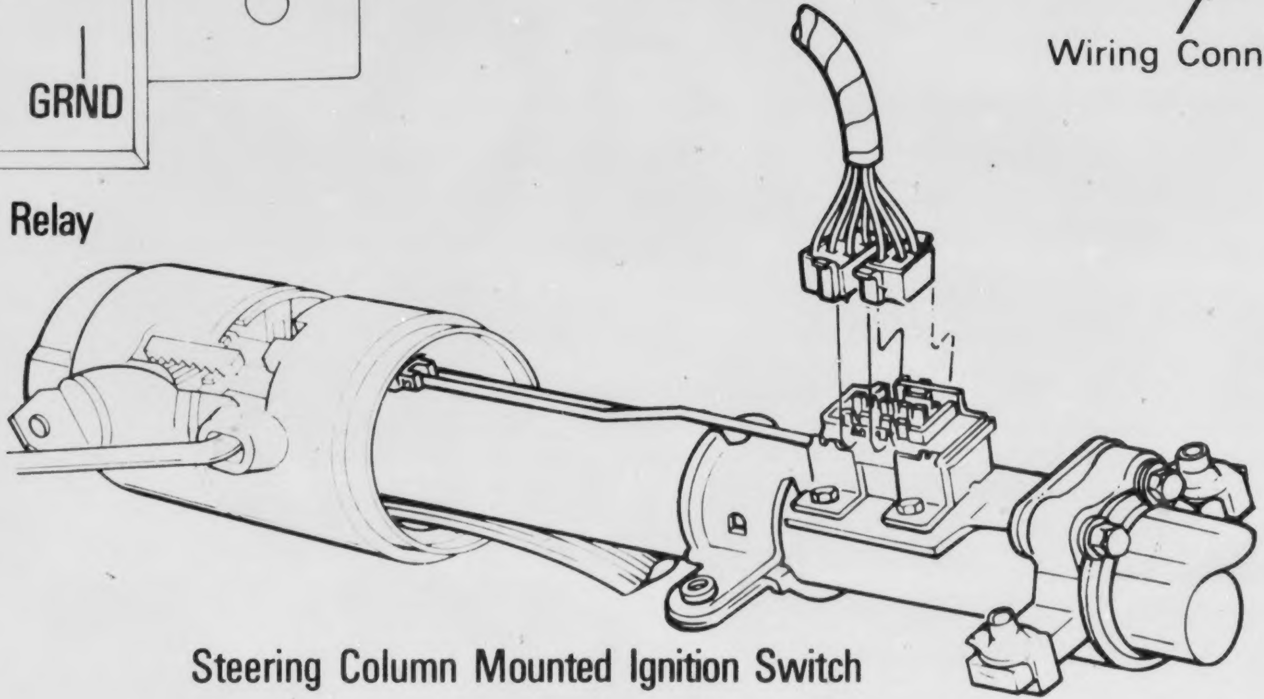
Starter Control Circuit Components


Bat
Sol
IGN
GRND

Starter Relay


Contact
Seal
Switch
Wiring Connector

Transmission Mounted Neutral-Start Switch



Steering Column Mounted Ignition Switch

STARTING SYSTEM
UNIT III

JOB SHEET #1--LOAD TEST A STARTER

I. Tools and equipment

A. Battery-starter tester

B. Battery hydrometer

C. Basic hand tool set

D. Safety glasses

E. Fender cover

II. Procedure

(NOTE: The engine should be at normal operating temperature to obtain an accurate test.)

A. Put on safety glasses

B. Raise the vehicle hood

C. Cover the fender next to the battery

D. Disconnect the ignition coil secondary load from the distributor cap; ground the lead

E. Test battery specific gravity

(NOTE: The battery must have a least 3/4 charge before proceeding with the starter load test.)

F. Turn the variable resistor control knob on the tester to the Off position

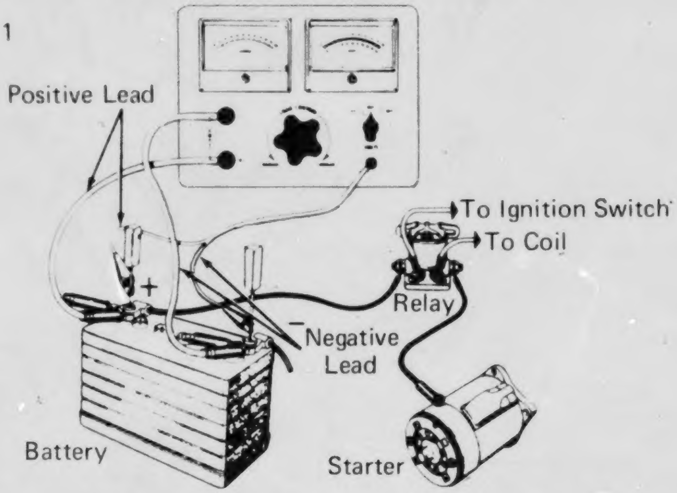
G. Connect the tester ammeter leads to the battery

H. Set voltmeter selector to the 16-volt scale (Figure 1)

JOB SHEET #1

I. Connect the voltmeter leads to the battery (Figure 1)

FIGURE 1



J. Connect a remote starter switch according to manufacturer's instructions

K. Crank the engine long enough to read the cranking voltage; record readings

(CAUTION: Do not crank the engine longer than 15 seconds at a time without allowing the starter to cool.)

L. Turn the variable resistor control knob on the tester until the voltmeter reads the cranking voltage previously recorded; read the equivalent of the starter current draw or load on the ammeter

(CAUTION: Do not leave the variable resistor control knob on longer than 15 seconds.)

(NOTE: Most starters will draw 150 to 250 amps on the load test, which indicates proper operation. If the amperage is significantly higher, the starter must be removed for further tests and repairs.)

M. Confer with instructor on test results

N. Clean up and store tools

STARTING SYSTEM
UNIT III

JOB SHEET #2--TEST STARTER CIRCUIT RESISTANCE

I. Tools and equipment

   A. Voltmeter

   B. Basic hand tools

   C. Fender covers

   D. Safety glasses

II. Procedure

(NOTE: In order to check the voltage drop or resistance in a circuit, it is necessary to have current flowing in the circuit. Therefore, all of the following test readings will be taken while the engine is cranking. High resistance in the supply circuit wiring or connections will cause the starter to crank the engine at a slower than normal rate.)

(CAUTION: Do not crank the engine longer than 15 seconds at one time without allowing the starter to cool.)

   A. Raise the vehicle hood

   B. Protect the fenders with appropriate covers

   C. Disconnect the coil lead from the distributor cap and connect to a good ground, or remove the distributor primary lead on high energy ignition systems

   (NOTE: This is to prevent the engine from starting during test procedures.)

   D. Set voltmeter to read on lowest scale

   E. Test starting system insulated circuit

   (NOTE: The following connections are for a negative ground system; reverse leads for a positive ground system.)

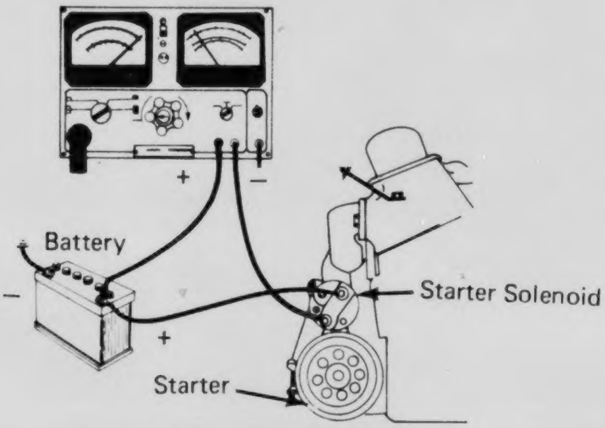
      1. Connect voltmeter positive test lead to the battery positive post (Figure 1)

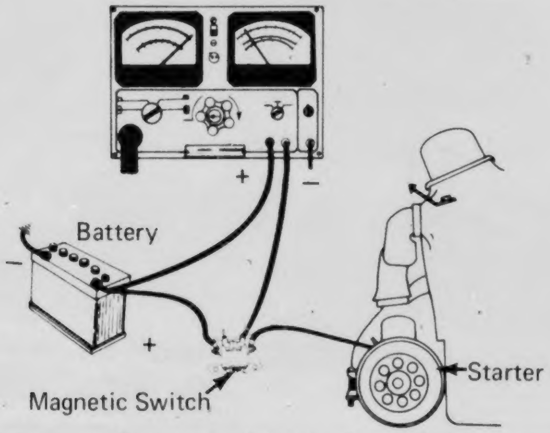
JOB SHEET #2

2. Connect voltmeter negative test lead to the starter terminal (Figure 1)

(NOTE: Select the system similar to the one on which you are working.)

FIGURE 1


+
–
Battery
–
+
Starter Solenoid
Starter


+
–
Battery
–
+
Starter
Magnetic Switch

3. Crank the engine and observe the voltmeter readings while cranking

(NOTE: The readings should be within the specifications of the manufacturer or those in the chart in Figure 2.)

FIGURE 2

Maximum allowable voltage drop in the insulated starter circuit

	6-volt system	12-volt system
Each cable	0.1	0.2
Each connection	0.0	0.0
Each switch	0.1	0.1
Starter solenoid switch	0.3	0.3
Total circuit voltage drop	0.4	0.5

JOB SHEET #2

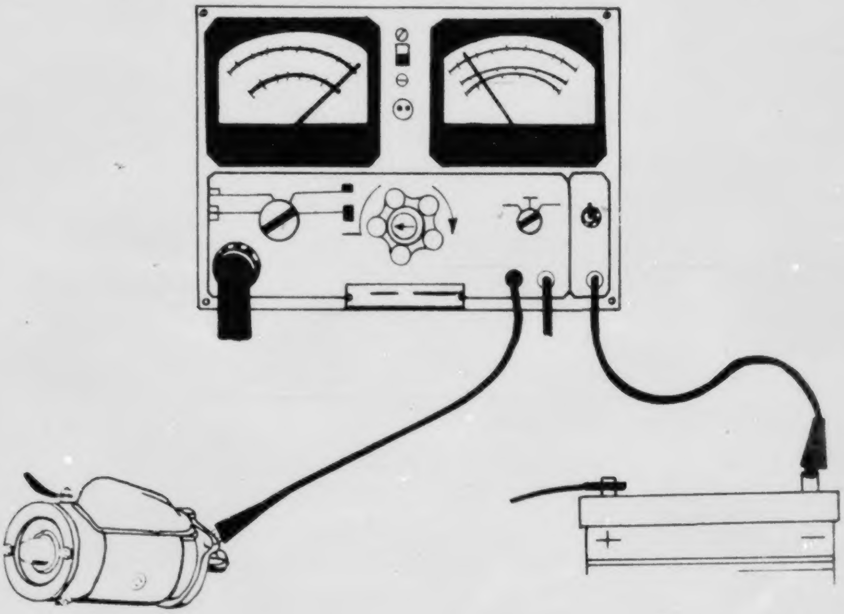
F. Test starting system ground circuit resistance

1. Connect the voltmeter positive lead to the starter frame (Figure 3)

   (NOTE: Be sure you have a good connection by scraping the starter frame where the connection is made.)

2. Connect the voltmeter negative lead to the battery negative post (Figure 3)

FIGURE 3



3. Crank the engine and observe voltmeter reading while cranking

   (NOTE: The readings should be within specifications of manufacturer or those in the chart in Figure 4.)

FIGURE 4

Maximum allowable voltage drop in the starter ground circuit

Total ground circuit voltage drop	6 volt system 0.1 volt	12 volt system 0.2 volt

G. Confer with your instructor on test results

H. Clean up and store tools

STARTING SYSTEM
UNIT III

JOB SHEET #3--TEST STARTER CONTROL CIRCUIT RESISTANCE

I. Tools and equipment

- A. Voltmeter
- B. Basic hand tool set
- C. Fender covers
- D. Seat cover
- E. Safety glasses

II. Procedure

(NOTE: Consult manufacturer's wiring diagram to identify the components in the control circuit such as the ignition switch, neutral-start switch, starter relay, magnetic switch, solenoid windings, or seat-belt interlock system. These components are connected in series so that any one component with high resistance will affect the total control circuit.)

- A. Raise vehicle hood
- B. Protect the fenders with covers
- C. Protect driver's seat with seat cover
- D. Set voltmeter to read on lowest scale
- E. Disconnect the coil lead from the distributor cap and connect to a good ground, or remove the distributor primary lead on high energy ignition systems
- F. Test complete control circuit resistance

  (NOTE: The following connections are for a negative ground system; reverse leads for a positive ground system.)

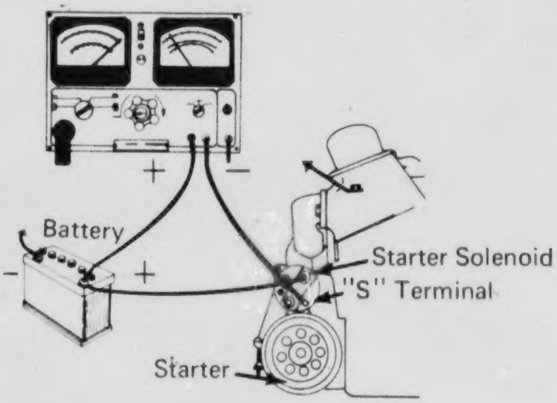
  1. Connect positive voltmeter lead to battery positive post (Figure 1)

JOB SHEET #3

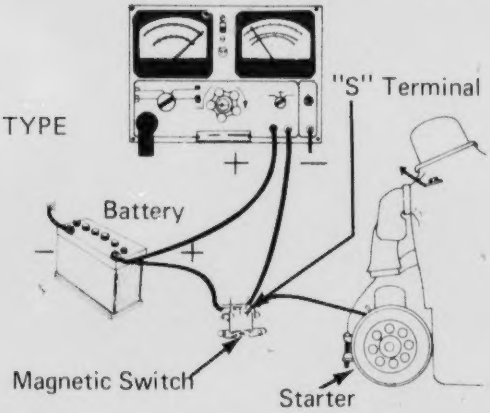
2. Connect voltmeter negative lead to "S" terminal on solenoid or magnetic switch (Figure 1)

FIGURE 1

SOLENOID TYPE


+
−
Battery
−
+
Starter Solenoid
"S" Terminal
Starter

MAGNETIC SWITCH TYPE


"S" Terminal
+
−
Battery
−
+
Magnetic Switch
Starter

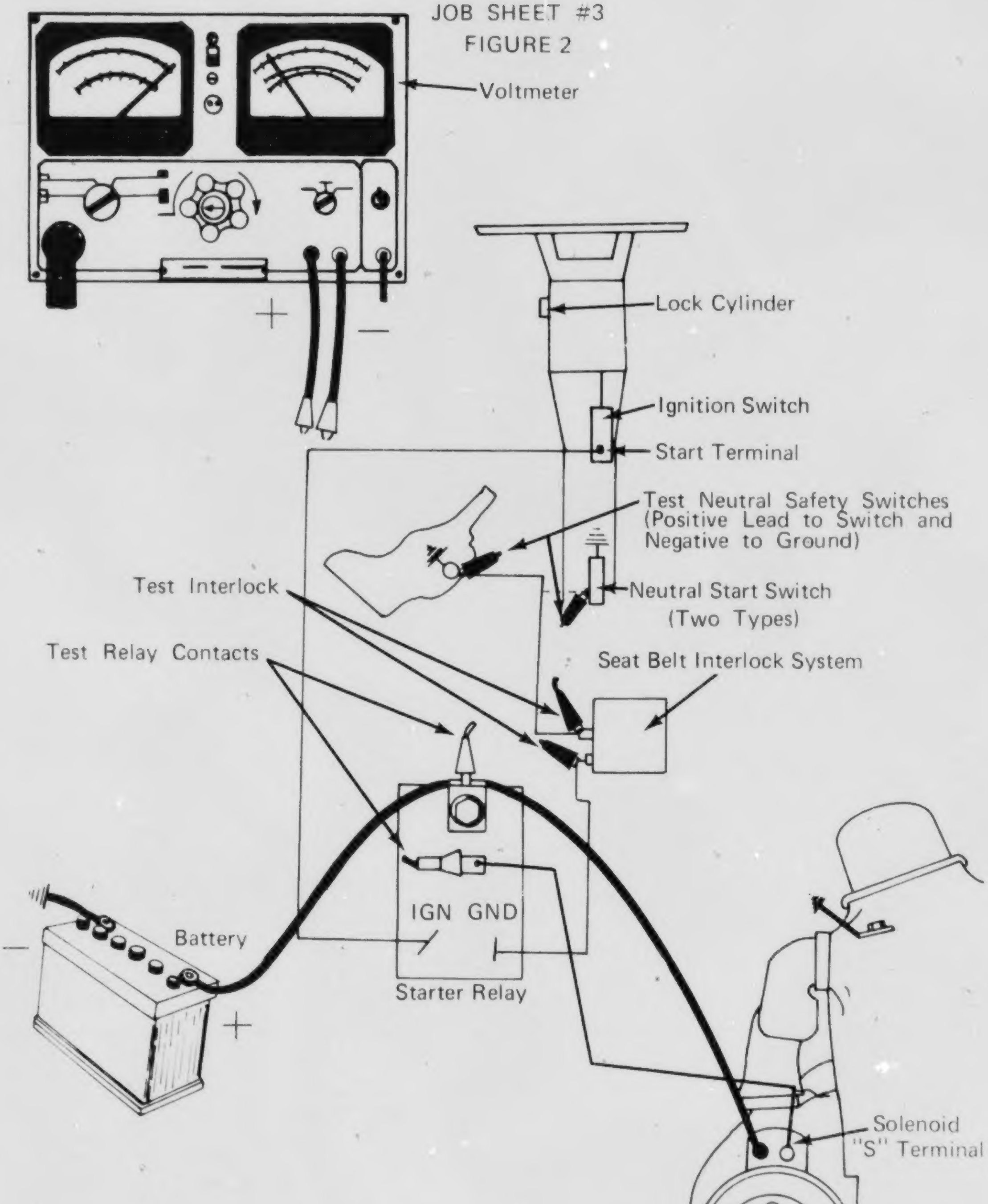
3. Crank the engine using the control switch, usually the ignition switch, while taking the voltage drop reading

   (NOTE: A voltage drop of less than 0.5 volts indicates the circuit is in good condition. A voltage drop of greater than 0.5 volts indicates excessive resistance. However, on certain vehicles slightly higher voltage drop could be normal.)

G. Isolate areas of high resistance by connecting the voltmeter leads across each component of the control circuit while observing polarity; check voltage drop readings with the starter control switch operated (Figure 2)

   (NOTE: A reading of more than 0.1 volt across any one wire or switch is usually an indication of trouble.)

JOB SHEET #3
FIGURE 2


Voltmeter
+
−
Lock Cylinder
Ignition Switch
Start Terminal
Test Neutral Safety Switches (Positive Lead to Switch and Negative to Ground)
Test Interlock
Neutral Start Switch (Two Types)
Test Relay Contacts
Seat Belt Interlock System
IGN GND
Battery
−
+
Starter Relay
Solenoid "S" Terminal
Starter

STARTING SYSTEM
UNIT III

JOB SHEET #4--REMOVE AND REPLACE A STARTER

I. Tools and equipment

- A. Combination end wrenches, 3/8" - 3/4" (8 mm - 20 mm)
- B. Sockets, 3/8" - 3/4" (8 mm - 20 mm), 3/8" drive
- C. Ratchet, 3/8" drive
- D. Extensions, 3" (75 mm) and 6" (150 mm), 3/8" drive
- E. Small ignition wrench set
- F. Battery cable pliers
- G. Jack
- H. Jack stands
- I. Creeper

II. Procedure

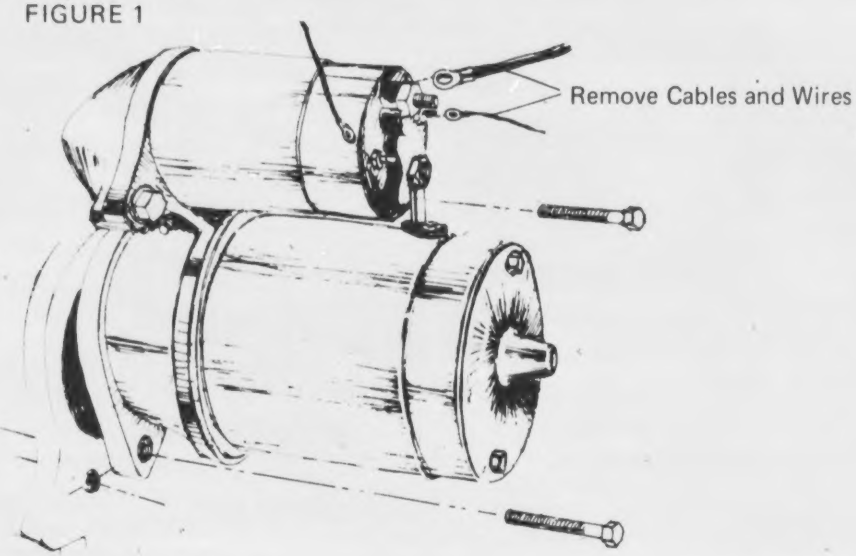
- A. Remove starter
  1. Disconnect battery ground cable
  2. Suspend vehicle on jack stands
  3. Remove the cables and electrical wires from the starter

     (NOTE: In some cases it may be necessary to remove the starter retaining bolts and allow the starter to be lowered to provide easy removal of the starter wires and cables.)

JOB SHEET #4

4. Remove starter retaining bolts as required (Figure 1)

FIGURE 1



5. Remove other starter brackets if used

6. Remove starter from engine

(CAUTION: Starters are heavy and should be handled carefully during removal to avoid damage to the starter or injury to the worker.)

B. Replace starter

1. Clean starter and block mounting surfaces

2. Position starter in mounting position and start retaining bolts

3. Tighten starter retaining bolts securely

4. Position starter wires and cables in place and start retaining nuts

5. Tighten starter wires and retaining nuts securely

   (NOTE: Avoid overtightening and twisting off small retaining nuts.)

6. Replace any brackets that may have been removed; tighten brackets securely

JOB SHEET #4

7. Check all connections

8. Remove jack stands and lower vehicle to floor

9. Replace battery ground cable

10. Start engine two or three times to check starter action

STARTING SYSTEM
UNIT III

JOB SHEET #5--DISASSEMBLE, CHECK, AND REASSEMBLE A STARTER

I. Tools and equipment

   A. Combination end wrenches, 3/8" - 3/4" (8 mm - 20 mm)

   B. Needle nose pliers

   C. Pliers, 2

   D. Hammer

   E. Small wooden block

   F. Suitable armature growler and test light

II. Procedure

   A. Disassemble starter

      1. Disconnect field coil connectors from solenoid

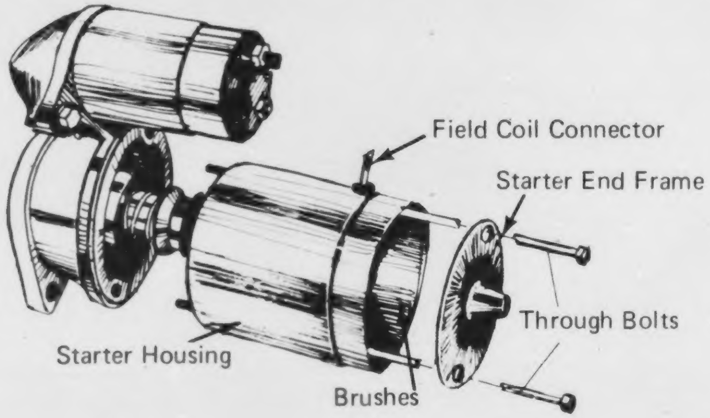
      2. Remove through bolts

      3. Remove starter end frame

      4. Remove starter housing by pulling it off over the front of the armature

      5. Remove the armature and drive assembly from the drive housing (Figure 1)

FIGURE 1


Field Coil Connector
Starter End Frame
Through Bolts
Starter Housing
Brushes

JOB SHEET #5

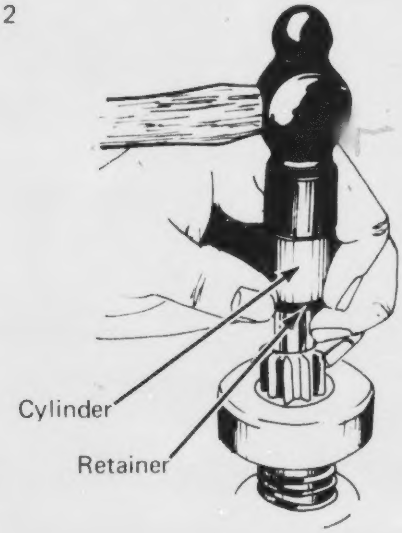
(NOTE: Sometimes the solenoid and shift lever assembly must be removed before the drive assembly and armature can be removed.)

6. Remove starter drive from armature shaft using the following steps

   a. Remove thrust washer

   b. Tap retainer toward armature to free the snap ring (Figure 2)

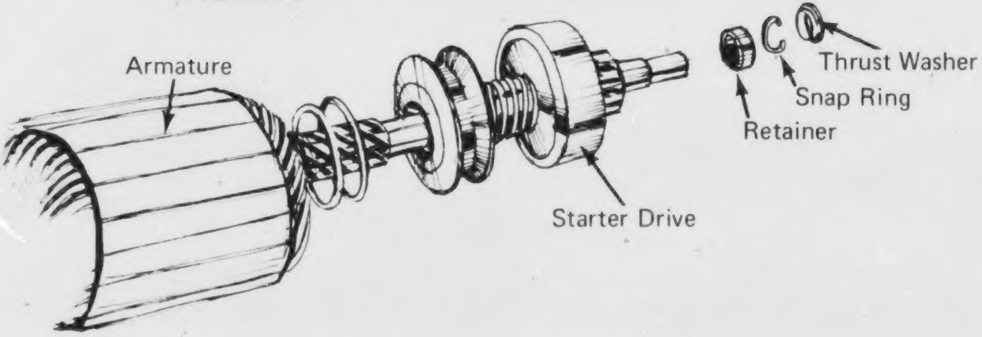
FIGURE 2


Cylinder
Retainer

   c. Remove snap ring and retainer

   d. Remove starter drive and assist spring (Figure 3)

FIGURE 3


Armature
Thrust Washer
Snap Ring
Retainer
Starter Drive

7. Remove starter brushes if required

JOB SHEET #5

B. Check condition of starter

1. Clean all starter components

   (NOTE: Clean all parts by wiping with clean cloths. The armature, field coils, and starter drive assembly must not be washed in solvent. Check starter frame for thrown solder from the armature commutator connections.)

2. Arrange all starter components for inspection

3. Check starter bushings for looseness and replace as required

4. Check starter brushes for wear

   (NOTE: Brushes worn to half their original length or more should be replaced.)

5. Check the starter drive

   a. Check gear teeth for wear

   b. Check bushing for wear

   c. Check starter drive pinion gear to make sure it turns freely in one direction and locks when turned in the other direction

6. Inspect armature commutator and recondition as required

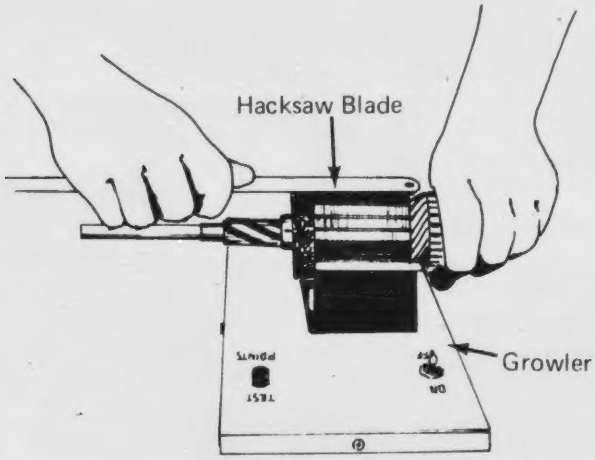
   (NOTE: If the armature commutator is rough or out of round, it should be turned down using suitable equipment.)

JOB SHEET #5

7. Check the armature for short circuits (Figure 4)

(NOTE: Place the armature on a growler and rotate the armature while holding a hacksaw blade over the armature core. If the blade vibrates, the armature is shorted and will require replacement.)

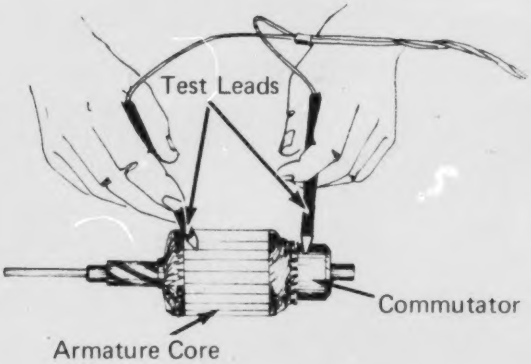
FIGURE 4


Hacksaw Blade
Growler
TEST POINTS

8. Check armature for ground (Figure 5)

(NOTE: Place one lead of a test lamp on the armature core or shaft and the other on each segment of the commutator. If the lamp lights, the armature is grounded and will require replacement.)

FIGURE 5

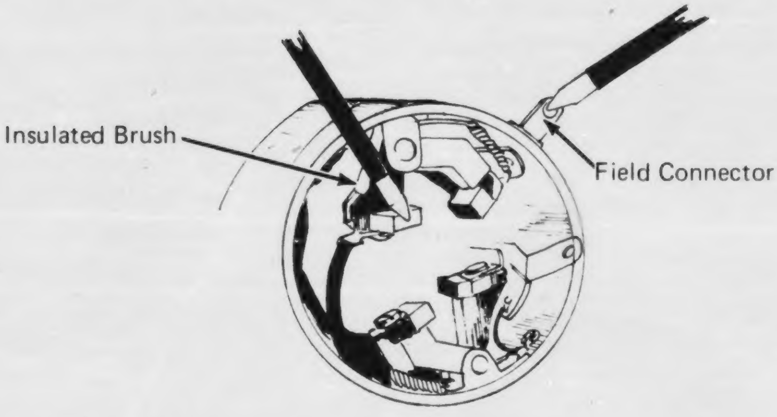

Test Leads
Commutator
Armature Core

JOB SHEET #5

9. Check field coil for open circuit (Figure 6)

   (NOTE: Place one lead of the test lamp on the insulated brush and the other on the field connection tab. If the lamp does not light, the field coils are open and will require replacement.)

   FIGURE 6



10. Check field coil for ground (Figure 7)

    a. Disconnect the shunt field and/or self-energizing switch and insulate from the starter frame if so equipped

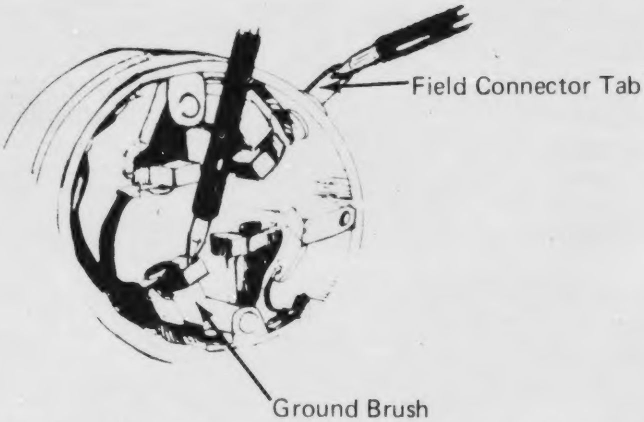
    b. Check shunt field by touching one test lamp lead to either of the shunt field wires and the other test lamp lead to the starter frame

    c. Check field coils by touching one test lamp lead to the field connector tab or post and the other lead to the starter frame

       (NOTE: If the lamp lights in either test, the field coils are grounded and will require replacement.)

JOB SHEET #5

FIGURE 7

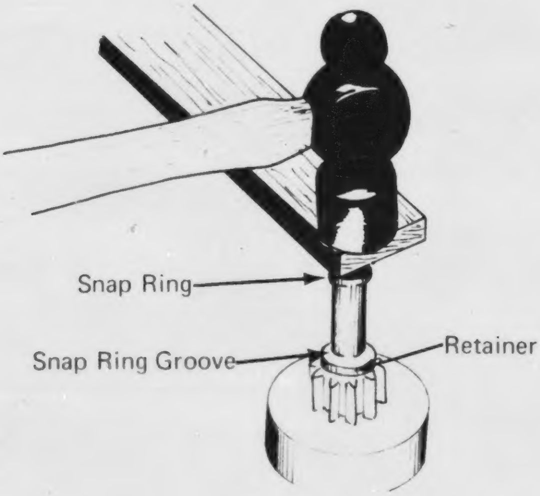

Field Connector Tab
Ground Brush

(NOTE: After all parts have been tested and inspected and worn or damaged parts have been replaced, the starter is ready to be reassembled.)

C. Reassemble starter

1. Assemble and install starter brush rigging if required
2. Attach wires to starter brush assemblies
3. Install assist spring on armature shaft
4. Install starter drive on armature shaft
5. Install retainer and snap ring (Figure 8)

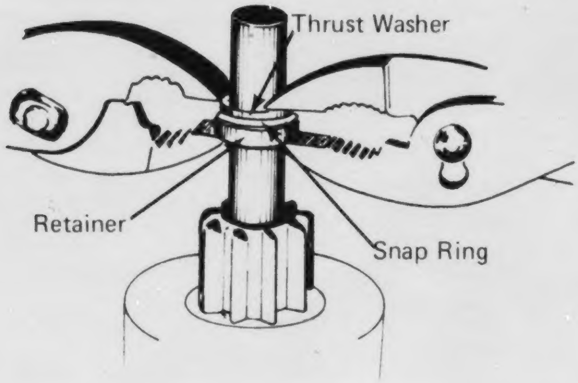
FIGURE 8


Snap Ring
Snap Ring Groove
Retainer

JOB SHEET #5

6. Force snap ring into retainer (Figure 9)

FIGURE 9



7. Lubricate drive housing bushing with four to five drops of light oil

8. Make sure thrust collar is in place against snap ring and retainer

9. Slide armature and starter drive assembly into place in drive housing, engaging shift lever with starter drive as required

   (NOTE: Install solenoid if removed.)

10. Position field frame over armature

    (NOTE: Use care when positioning field frame against drive housing to prevent damage to the brushes.)

11. Place four to five drops of light oil on starter end frame bushing

12. Place leather brake washer on armature shaft

13. Install starter end frame and start through bolts

    (NOTE: Align lugs on the starter frame with drive housing hole. Align end frame lug with starter housing slot before tightening through bolts.)

14. Tighten through bolts evenly and securely

15. Reconnect the field coil connectors to the solenoid

16. Test starter with a battery and jumper cables to determine starter performance

STARTING SYSTEM
UNIT III

JOB SHEET #6--DISASSEMBLE AND REASSEMBLE A GEAR REDUCTION STARTER

I. Tools

  A. Socket set, 3/8" drive

  B. Combination end wrenches, 5/16" - 5/8" (6 mm - 16 mm)

  C. Screwdriver set

  D. Soldering gun or iron

  E. Needle nose pliers

  F. Shop towels

  G. Resin core solder

  H. Light engine oil

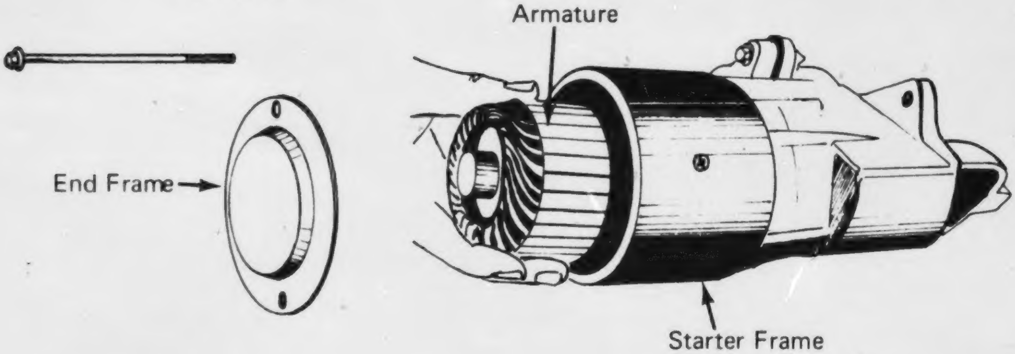
II. Procedure

  A. Disassemble starter

    1. Remove through bolts and end frame (Figure 1)

    2. Pull the armature from the starter frame (Figure 1)

FIGURE 1

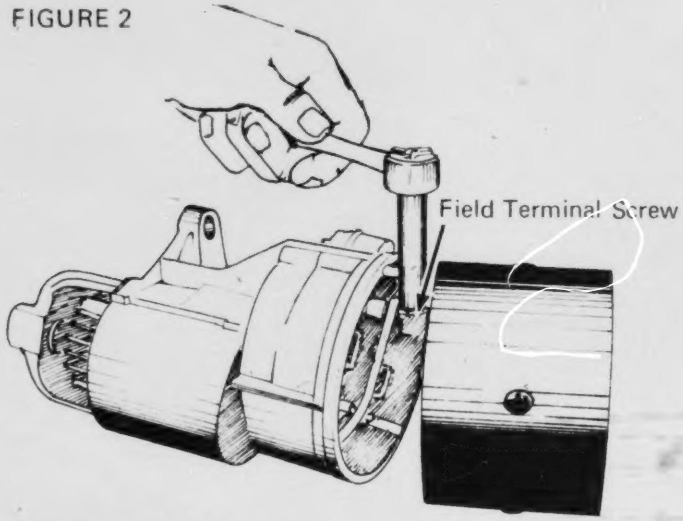


    3. Separate the starter frame from the gear housing just enough to expose the field terminal screw (Figure 2)

JOB SHEET #6

4. Remove the field terminal screw (Figure 2)

FIGURE 2


Field Terminal Screw

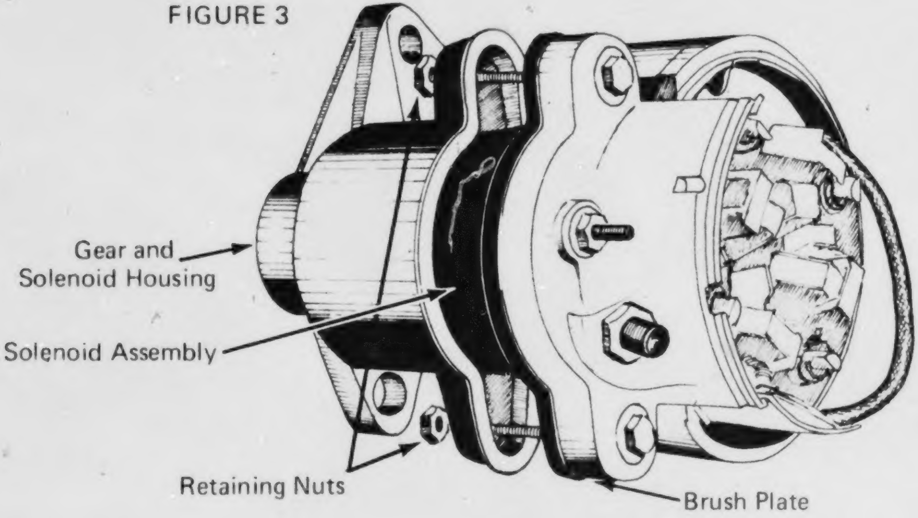
5. Remove the starter frame

6. Remove nuts from solenoid and brush plate retaining bolts (Figure 3)

7. Remove solenoid and brush plate assembly from the gear housing (Figure 3)

(NOTE: Separation of the solenoid and brush plate is not necessary unless they are to be replaced.)

FIGURE 3


Gear and Solenoid Housing
Solenoid Assembly
Retaining Nuts
Brush Plate

JOB SHEET #6

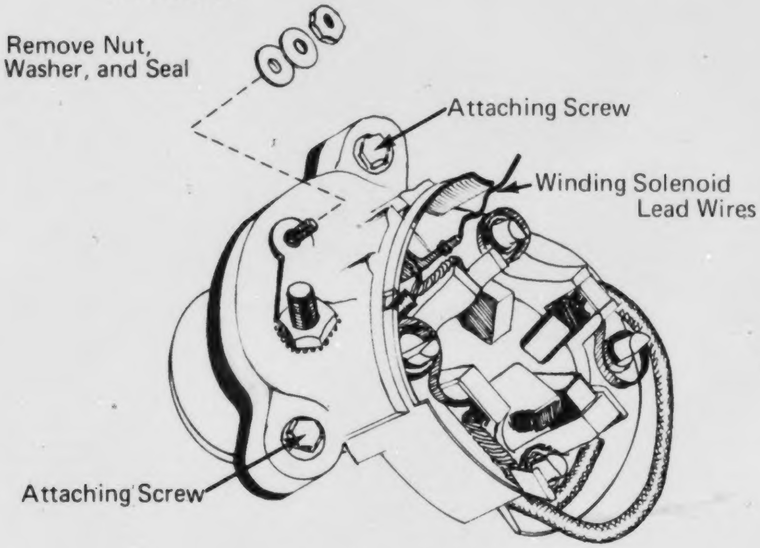
8. Remove the solenoid from the brush plate

   a. Unwind the solenoid wire from the brush terminal on the brush plate (Figure 4)

   b. Remove the nut, washer, and seal from the solenoid terminal (Figure 4)

   c. Remove screws attaching solenoid to brush plate (Figure 4)

FIGURE 4


Remove Nut, Washer, and Seal
Attaching Screw
Winding Solenoid Lead Wires
Attaching Screw

   d. Remove solenoid from the brush plate

   e. Remove solenoid contact and plunger assembly

9. Remove the solenoid moving core and return spring from the gear housing

10. Remove dust cover from gear housing

    (NOTE: Refer to Figure 5 on the following page.)

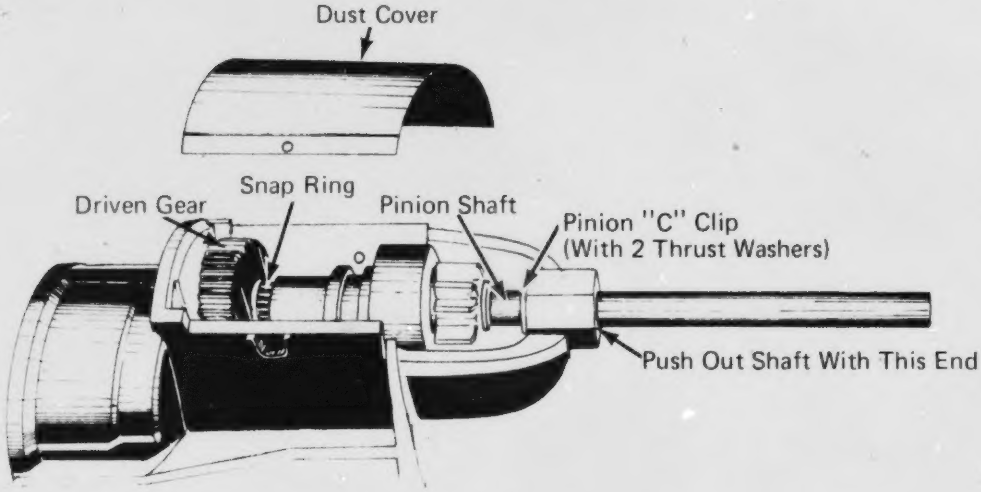
11. Release snap ring that positions driven gear on pinion shaft (Figure 5)

    (CAUTION: The snap ring is under tension; therefore, a cloth should be used to prevent it from springing away.)

JOB SHEET #6

12. Remove pinion shaft "C" clip or snap ring (Figure 5)

FIGURE 5


Dust Cover
Snap Ring
Driven Gear
Pinion Shaft
Pinion "C" Clip
(With 2 Thrust Washers)
Push Out Shaft With This End

13. Push the pinion shaft out of the gear housing
14. Remove the driven gear and its thrust washer
15. Remove starter drive and its thrust washers
16. Remove the shifting fork pin and take out shifting fork

    (NOTE: Refer to Figure 6 on the following page.)

17. Clean parts and inspect for wear

    (CAUTION: The armature, field coils, and starter drive unit must not be washed in solvent. Wipe these parts with a clean cloth.)

    (NOTE: Procedures for testing and inspecting the parts of this starter are the same as those in Job Sheet #5.)

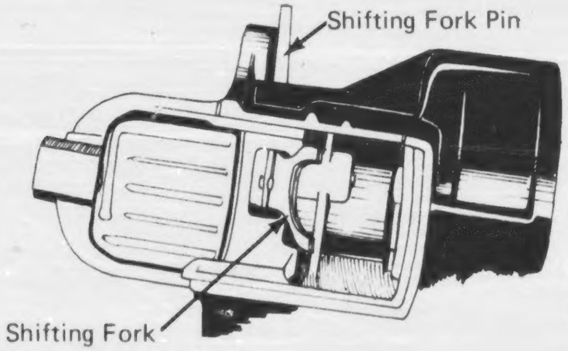
18. Replace worn and defective parts as necessary

JOB SHEET #6

B. Reassemble starter

1. Replace shifting fork and secure with shifting fork pin by placing the halves of the pin on each side of the fork and between the rivets on the fork (Figure 6)

FIGURE 6


Shifting Fork Pin
Shifting Fork

2. Start pinion shaft in the gear housing

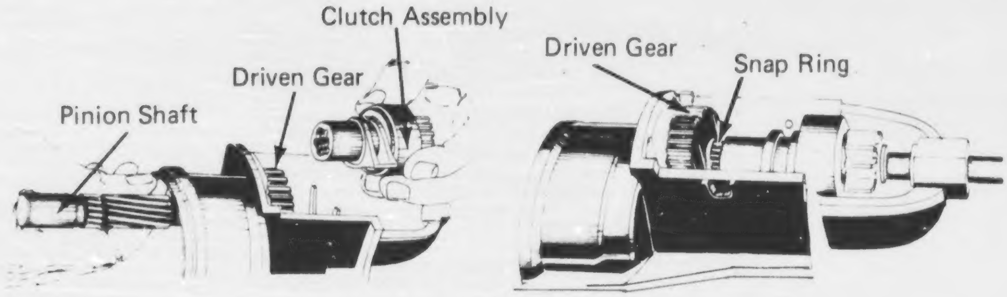
3. Position the driven gear thrust washers and driven gear over the end of the shaft (Figure 7)

4. Position the starter drive in the gear housing so that the shift fork engages the plastic rails on the drive unit (Figure 7)

5. Slide the pinion shaft through the drive unit and install the thrust washers and "C" clip on the shaft (Figure 7)

6. Position the pinion shaft inward against the thrust washer and the driven gear against the gear housing and install the snap ring next to the driven gear (Figure 7)

FIGURE 7


Clutch Assembly
Driven Gear
Pinion Shaft
Driven Gear
Snap Ring

JOB SHEET #6

7. Install solenoid return spring into movable core

8. Install core and spring into starter gear housing engaging it into the shift fork

9. Install contact plunger assembly into solenoid

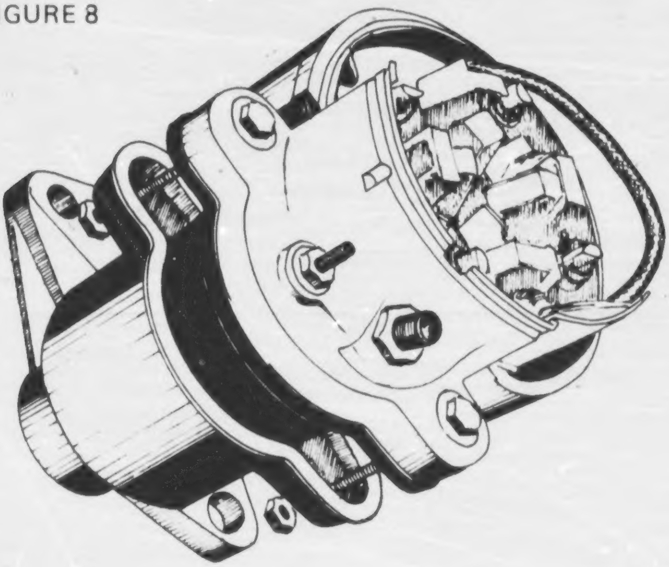
10. Install solenoid and gasket on brush plate and secure with retainer screws

11. Wrap solenoid lead wire around brush terminal and solder

12. Install seal, flat washer, and nut on solenoid terminal

13. Install solenoid and brush plate into starter gear housing and secure with attaching nuts (Figure 8)

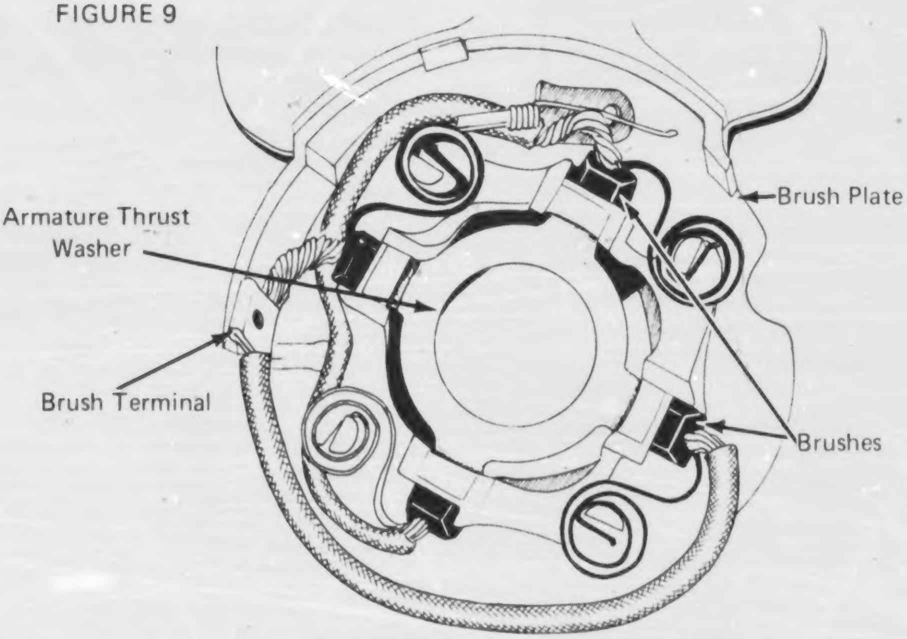
FIGURE 8



JOB SHEET #6

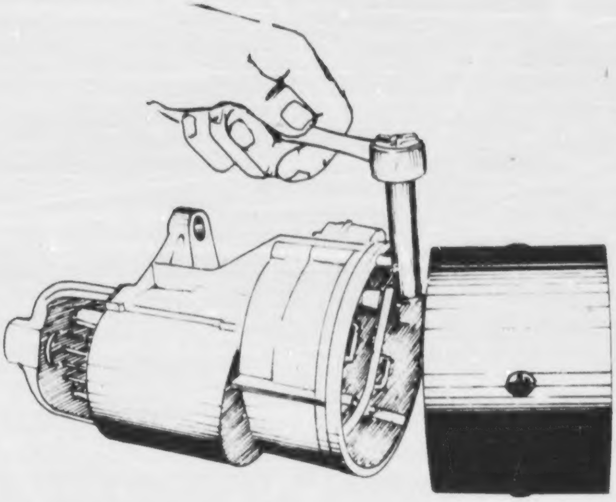
14. Position armature tabbed thrust washer inside brushes (Figure 9)

FIGURE 9


Armature Thrust Washer
Brush Plate
Brush Terminal
Brushes

15. Install brush terminal screw (Figure 10)

FIGURE 10



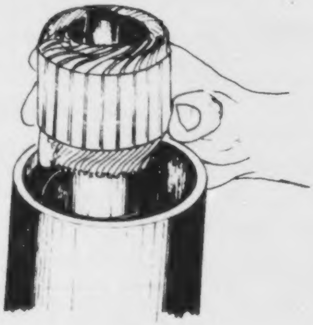
16. Position starter frame to the exact position on the gear housing

JOB SHEET #6

17. Install the fiber thrust washer on the drive end of the armature

18. Install the armature into the starter frame, while guiding it through the steel thrust washer, until it bottoms in the gear housing (Figure 11)

FIGURE 11



19. Install thrust washer on the armature shaft

20. Position the end frame on the starter

21. Install through bolts and tighten evenly and securely

22. Test starter performance with battery and jumper cables

STARTING SYSTEM
UNIT III

TEST

NAME ______________________________ SCORE ____________________

1. Match the terms on the right to the correct definitions.

_____a. Coil or winding in a generator or starter which produces a magnetic field as current passes through it

_____b. Device for reversing the direction of current flowing through the conductors of the rotating armature in a motor

_____c. Device used to transmit power produced in starter to automobile engine

_____d. Housing for starter and mounting for field coils and pole shoes

_____e. Series of loops of wire arranged around a shaft and made to rotate due to magnetic reaction

_____f. Tubular field coil with a movable metal core used to engage the starter drive with the flywheel and to close the starter switch

_____g. Sliding contact used to pass electrical current to a rotating armature

_____h. Starter which contains a set of gears that reduces its cranking speed and increases the torque

_____i. Solid or laminated metal core inside a field coil used to concentrate the magnetic lines of force to produce a strong magnet

1. Starter drive
2. Solenoid
3. Brush
4. Armature
5. Commutator
6. Frame
7. Field coil
8. Pole shoe
9. Gear reduction starter

2. State the purpose of the starting system.

____

____

3. Describe the operating principle of the starter.

4. Discuss the magnetic principles of the starter.

5. Describe the current flow in a series wound starter.

6. List the components of the starting system.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

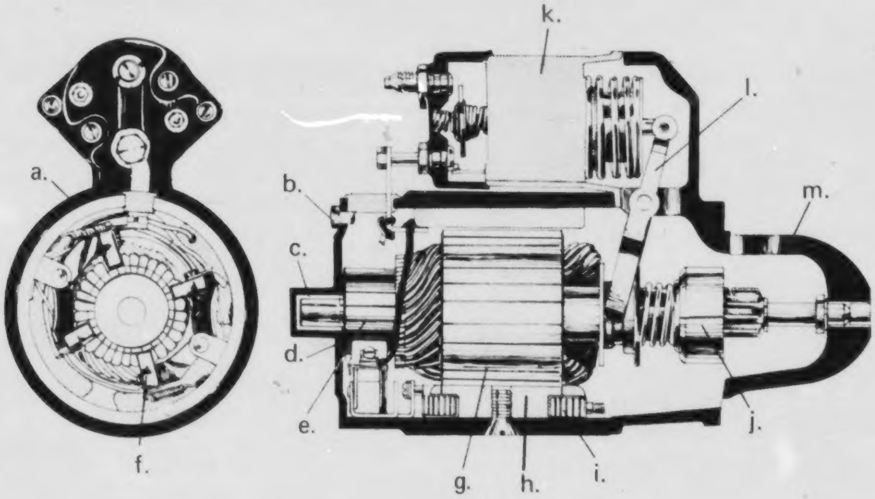
f. ____________________

7. Name the types of starter switches.

a. ____________________

b. ____________________

8. Identify the parts of the starter in the diagram below by writing the correct names in the blanks provided.



a. ____________ h. ____________

b. ____________ i. ____________

c. ____________ j. ____________

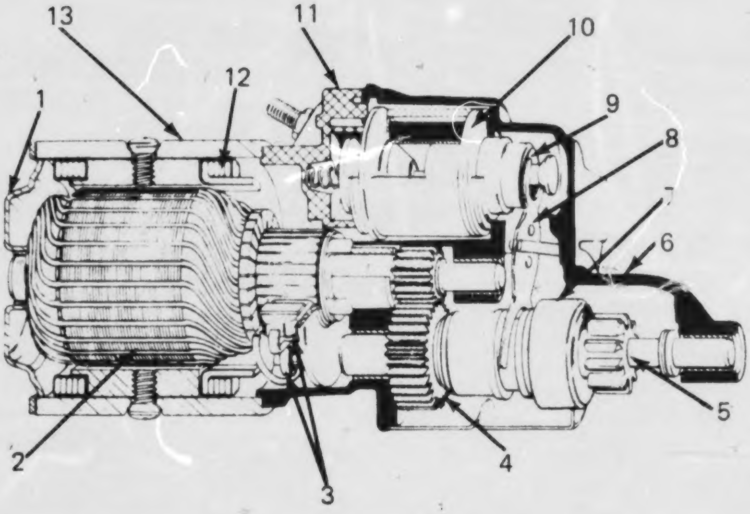
d. ____________ k. ____________

e. ____________ l. ____________

f. ____________ m. ____________

g. ____________

9. Identify the major parts of the gear reduction starter in the drawing below by placing the number in the blank next to the correct name.



_____a. Brush and spring

_____b. Solenoid assembly

_____c. Gear and solenoid housing

_____d. Brush plate

_____e. Pinion shaft

_____f. Reduction gearset

_____g. Armature

_____h. Shifter fork

_____i. Solenoid moving core

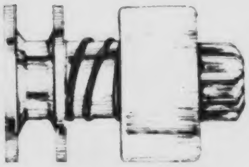
_____j. Clutch drive

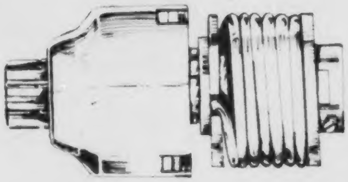
_____k. Starter frame

_____l. Starter field

_____m. End frame

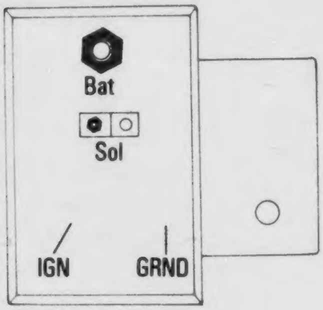
10. Identify the types of starter drives in the diagrams below.

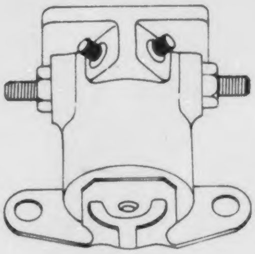




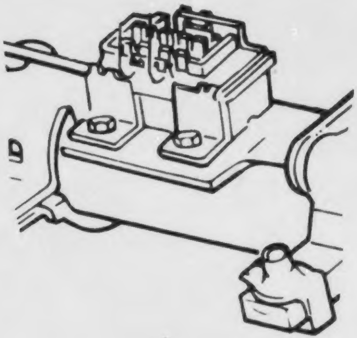
a. ____________________ b. ____________________

11. Identify the components of the starter control circuit shown below.

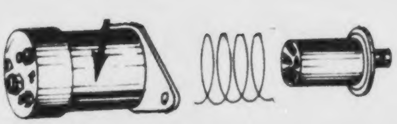


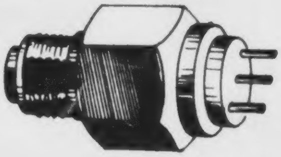


a. ____________________ b. ____________________



c. ____________________





d. ____________________ e. ____________________

12. Match the starting system control circuit components on the right to the correct functions.

______a. Opens the starter control circuit unless the passengers in the front seat connect their seat belts

______b. Initiates the control circuit current

______c. Shifts the starter drive gear in mesh with the flywheel and then closes the heavy contact switch between the battery and starter

______d. Closes circuit between the battery and starter

______e. Connects the starter solenoid to the battery when its contacts are closed

______f. Opens the control circuit when the automatic transmission selector lever is not in neutral or park

1. Ignition switch
2. Neutral-start switch
3. Seat-belt starter interlock system
4. Starter relay
5. Starter solenoid
6. Magnetic starter switch

13. Demonstrate the ability to:

a. Load test a starter.

b. Test starter circuit resistance.

c. Test starter control circuit resistance.

d. Remove and replace a starter.

e. Disassemble, check, and reassemble a starter.

f. Disassemble and reassemble a gear reduction starter.

(NOTE: If the above activities have not been accomplished prior to the test, ask the instructor when they should be completed.)

STARTING SYSTEM
UNIT III

ANSWERS TO TEST

1. a. 7
   b. 5
   c. 1
   d. 6
   e. 4
   f. 2
   g. 3
   h. 9
   i. 8

2. To convert electrical energy from the battery into mechanical energy at the starter to crank the engine

3. Description should include:

   The small electric motor with heavy windings of very low resistance carries a high amperage current (150 to 250 amps) at a low voltage for a short period of time

4. Discussion should include:

   a. Like magnetic fields repel and opposite magnetic fields attract each other

   b. Current flow in a conductor creates a magnetic field around the conductor

   c. Stationary field between poles of magnet interacts with magnetic field around conductor

   d. Lines of force oppose each other on one side of conductor and reinforce each other on the other side

5. Description should include:

   a. High amperage current flows from battery to starter through heavy battery cable

   b. Current enters motor at large cable terminal and travels through field coils

   c. Field coils are connected to insulated brushes which pass current to armature

   d. Current passes through armature windings and back to grounded brushes

   e. Grounded brushes return current to ground and back to battery

6. a. Battery

   b. Key switch

c. Starter switch

d. Starter

e. Small gauge switch wire

f. Battery cables

7. a. Solenoid

b. Magnetic

8. a. Starter frame

b. Through bolt

c. Bushing

d. End frame

e. Commutator

f. Starter brush

g. Armature

h. Pole shoe

i. Field coil

j. Starter drive

k. Solenoid

l. Shift lever

m. Drive housing

9. a. 3

b. 10

c. 6

d. 11

e. 5

f. 4

g. 2

h. 8

i. 9

j. 7

k. 13

l. 12

m. 1

10. a. Overrunning clutch

b. Folo-thru bendix

11. a. Starter relay

b. Magnetic switch

c. Ignition switch

d. Solenoid

e. Neutral-start switch

12. a. 3 d. 6
    b. 1 e. 4
    c. 5 f. 2

13. Performance skills should be evaluated to the satisfaction of the instructor

IGNITION SYSTEM
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify the components of the various ignition systems and match the components to their functions. The student should be able to discuss the operation of the ignition system and demonstrate the ability to service the ignition system. This knowledge will be evidenced through demonstration and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with the ignition system to the correct definitions.
2. State the purpose of the ignition system.
3. Identify the components of the ignition system.
4. Match the components of the ignition system to the correct functions.
5. Identify the components of the distributor.
6. Distinguish between the components of the primary and secondary ignition circuits.
7. Discuss in writing the operation of the ignition system through one complete cycle, beginning with the battery.
8. Identify the parts of a spark plug.
9. Label spark plugs according to heat range.
10. Match causes to spark plug conditions.
11. Name the types of secondary ignition cables.
12. Distinguish between the transistorized and capacitive discharge ignition systems.
13. Discuss the relationship of the electronic ignition system to the conventional ignition system.
14. List advantages of the electronic ignition system.
15. Identify the major components of an electronic ignition system.

16. Match the major components of the electronic ignition system to the correct functions.

17. Arrange in order the operation of the electronic ignition system.

18. Demonstrate the ability to:

    a. Check and set ignition timing.

    b. Remove and replace a distributor.

    c. Remove and replace contact points and condenser.

    d. Adjust dwell on an externally adjustable distributor.

    e. Test and adjust distributor on distributor tester.

    f. Remove, inspect, service, and replace spark plugs.

IGNITION SYSTEM
UNIT IV

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

  A. Provide student with objective sheet.

  B. Provide student with information and job sheets.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information sheet.

  F. Demonstrate and discuss the procedures outlined in the job sheets.

  G. Give test.

II. Unit references:

  A. *Electrical Systems.* Fundamentals of Service Series. Moline, Illinois: Deere and Co., 1972.

  B. Billiet, Walter E., and Goings, Leslie F. *Automotive Electrical Systems.* 3d ed. Chicago: American Technical Society, 1970.

  C. Crouse, William H. *Automotive Mechanics.* 7th ed. New York: Webster Div./McGraw-Hill Book Co., 1975.

  D. *Chevrolet Chassis Overhaul Manual.* Detroit, Michigan: Chevrolet Motor Div./General Motors Corp., 1974.

  E. *Chrysler, Plymouth, Dodge Electrical Service Manual.* Detroit: Chrysler Corp., 1976.

  F. Crouse, William H. *Automotive Electrical Equipment.* 8th ed. New York: McGraw-Hill Book Co., 1976.

  G. *Ford Electrical Car Shop Manual.* Dearborn, Michigan: Ford Motor Co., 1975-76.

IGNITION SYSTEM
UNIT IV

INFORMATION SHEET

I. Terms and definitions

   A. Timing--Igniting the fuel-air mixture at the exact instant that will enable the engine to develop maximum power

   B. Primary ignition circuit--Low voltage circuit which energizes the ignition coil

   C. Secondary ignition circuit--High voltage circuit which produces electrical current to jump spark plug gap

   D. Dwell--Number of degrees of distributor cam rotation that the ignition points are closed

   E. Electronic ignition system--Ignition system using a control unit and magnetic pickup to open and close the primary circuit

   F. Ignition bypass circuit--Auxiliary primary ignition circuit that bypasses the resistance unit in the primary circuit to provide full battery voltage to the ignition system during starting

II. Purpose of the ignition system--To provide a high voltage spark to ignite the fuel-air mixture in the combustion chamber

III. Components of the ignition system (Transparency 1)

   A. Battery

   B. Ignition switch

   C. Primary resistance unit

   D. Ignition coil

   E. Contact points

   (NOTE: Contact points are also known as *breaker points*.)

   F. Condenser

   G. Distributor

   H. Breaker cam

   I. Spark-advance mechanism

   (NOTE: There are two types of spark-advance mechanisms, vacuum and mechanical. Engine vacuum controls timing advance in relation to engine load. Mechanical advance changes engine timing according to engine speed.)

INFORMATION SHEET

- J. Rotor
- K. Distributor cap
- L. Spark plug
- M. Primary ignition wire
- N. Secondary ignition cable

IV. Functions of the ignition system components (Transparency 1)

- A. Battery--Serves as a source of electrical power
- B. Ignition switch--Opens and closes the primary circuit from battery to the coil
- C. Resistance unit--Reduces voltage in the primary circuit to protect the contact points
- D. Ignition coil--Transforms low voltage into high voltage necessary to jump the spark plug gap
- E. Contact point or breaker point--Makes and breaks the primary circuit to allow the coil to produce high voltage at the spark plugs
- F. Condenser--Stores extra current as the contact points open to prevent arcing and burning; aids coil primary winding to build up magnetic field by releasing its charge back into the circuit as the points close
- G. Distributor--Contains the contact points and condenser; distributes the high voltage current from the coil to the proper cylinder
- H. Breaker cam--Opens and closes the contact points
- I. Spark-advance mechanism--Regulates the timing of the high voltage circuit for best ignition during all speed and load conditions
- J. Rotor--Takes the high voltage current from the coil and directs it to the correct cylinder
- K. Distributor cap--Holds the coil and spark plug wires in a sequence and provides a cover for the distributor
- L. Spark plug--Provides a spark gap inside the engine cylinder to ignite the fuel-air mixture
- M. Primary ignition wire--Carries low voltage from the battery to the primary windings of the ignition coil (light wire)
- N. Secondary ignition cable--Carries high voltage from the secondary windings of the coil to the spark plug (heavily insulated wire)

INFORMATION SHEET

V. Distributor components (Transparency 2)

- A. Distributor cap
- B. Rotor
- C. Centrifugal advance mechanism
- D. Condenser
- E. Vacuum advance unit
- F. Breaker plate
- G. Distributor cam
- H. Contact points
- I. Distributor housing
- J. Primary lead wire
- K. Distributor drive gear

VI. Components of the ignition system circuits

- A. Primary (Transparency 3)
  1. Battery
  2. Ignition switch
  3. Resistance unit
  4. Primary winding of the coil
  5. Contact points
  6. Condenser
  7. Low voltage wire
- B. Secondary (Transparency 4)
  1. Secondary winding of the coil
  2. Distributor cap
  3. Rotor
  4. Spark plug
  5. High voltage cable

INFORMATION SHEET

VII. Operation of the ignition system

A. With the ignition switch on and the contact points closed, low voltage current flows from the battery through the primary winding of the coil and through the contact points to ground (Transparency 5)

B. The flow of low voltage current through the primary windings of the coil causes a magnetic field buildup (Transparency 6)

C. As the contact points open, current continues to flow across the point surfaces; the condenser attached to the points absorbs this flow of current (Transparency 7)

D. Stopping this flow of current causes the magnetic field of the coil primary windings to collapse across the secondary coil windings, causing a high voltage surge (Transparency 8)

E. This high voltage surge is directed from the secondary windings of the coil through the distributor cap and rotor and on to the spark plug to ground (Transparency 9)

VIII. Parts of a spark plug (Transparency 10)

A. Ignition cable terminal

B. Center electrode resistance unit

C. Gas seal

D. Center electrode tip

E. Ground electrode

F. Steel shell

G. Porcelain insulator

IX. Spark plug heat ranges (Transparency 11)

(NOTE: Heat range is a function of the shape of the plug and the distance heat must travel from the center electrode of the plug to reach the cylinder head.)

A. Hot

B. Cold

INFORMATION SHEET

X. Spark plug conditions and causes (Transparency 12)

   A. Normal

      (NOTE: The insulator is brown to grayish tan in color with slight electrode wear.)

   B. Carbon deposits

      (NOTE: Dry deposits indicate rich mixture or weak ignition.)

   C. Oil deposits

      (NOTE: The condition is caused by poor oil control. Oil is leaking past worn valve guides or piston rings into the combustion chamber.)

   D. Too hot

      (NOTE: The spark plug will not have deposits, but the porcelain will be white and blistered with the center electrode eroded.)

   E. Preignition

      (NOTE: The spark plug will have melted electrodes with the center electrode generally melting first and the ground electrode following.)

   F. High-speed glazing

      (NOTE: The insulator has a yellowish, varnish-like color which indicates combustion chamber temperatures have risen suddenly during hard, fast acceleration.)

   G. Modifier deposits

      (NOTE: Powdery white or yellow deposits that build up on shell, insulator, and electrodes. This is a normal appearance with certain brands of fuels.)

   H. Splashed deposits

      (NOTE: Spotted deposits occur shortly after long delayed tune-up.)

XI. Types of secondary ignition cables

   A. Radio suppression

   B. Stranded wire

INFORMATION SHEET

XII. Transistorized and capacitive discharge ignitions

(NOTE: Both variations are designed to increase primary voltage to coil and reduce voltage at points.)

A. Transistorized ignitions

1. Amplifier is included in circuit between points and ignition coil

2. Transistors allow very low voltage through the points and battery voltage to the primary windings in coil

B. Capacitive discharge system

1. System contains special ignition distributor, amplifier, and special coil

2. System operates to charge a capacitor to a high voltage which, on signal from distributor, is then discharged through the primary windings in coil

XIII. Relationship of the electronic ignition system to the conventional ignition system--The electronic ignition system functions the same as the conventional ignition system; however, in the electronic system, an electronic control unit and its sensory device, a magnetic pickup, does the job of the ignition points of the conventional system

XIV. Advantages of electronic ignition system

A. Requires much less maintenance during the life of the vehicle

B. Has no moving parts in the primary circuit

C. Maintains a constant dwell at all engine speeds and operating conditions

D. Extends the efficient life of the spark plugs

XV. Major components of the electronic ignition system (Transparency 13)

A. Resistor unit

(NOTE: This component may not be used on all models.)

B. Control unit

C. Magnetic pickup assembly

INFORMATION SHEET

D. Armature

(NOTE: The armature is sometimes called a *reluctor* or *timer core*.)

XVI. Functions of the components of the electronic ignition system (Transparancy 13)

A. Resistance unit--Maintains constant primary current with variations in engine speed

(NOTE: The resistance unit is bypassed during engine starting.)

B. Magnetic pickup assembly--Sends a small voltage pulse to the control unit to trigger switching transistor to stop current flow in the coil primary windings

C. Armature or reluctor--Rotates with the distributor shaft, producing a voltage pulse in the magnetic pickup

(NOTE: The armature contains the same number of teeth as the engine contains cylinders.)

D. Control unit--Controls the flow of current in the primary windings of the ignition coil and maintains dwell

XVII. Operation of electronic ignition system (Transparency 14)

A. With ignition switch On and the armature tooth not aligned with the magnetic pickup, the primary circuit has current flowing from the ignition switch to the resistance unit (if used) through the primary windings of the coil through the control unit to ground

B. As the armature tooth approaches the magnetic pickup, the voltage begins to build up in the magnetic pickup circuit

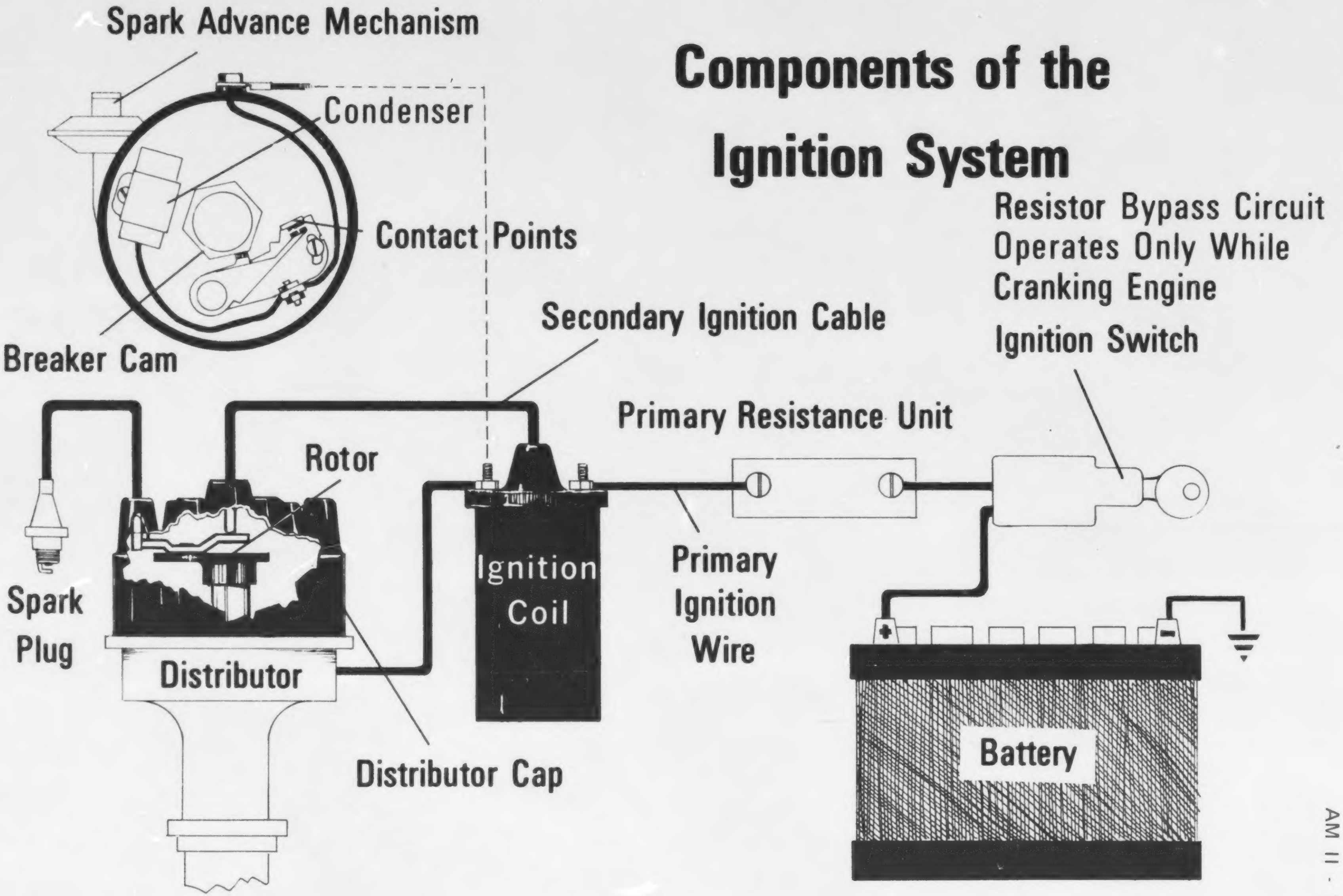
C. As the armature tooth aligns with the magnetic pickup, the voltage in the magnetic pickup circuit is sufficient to signal the switching transistor to shut off current flow in the primary circuit

(NOTE: This is the equivalent of the points opening on the conventional ignition.)

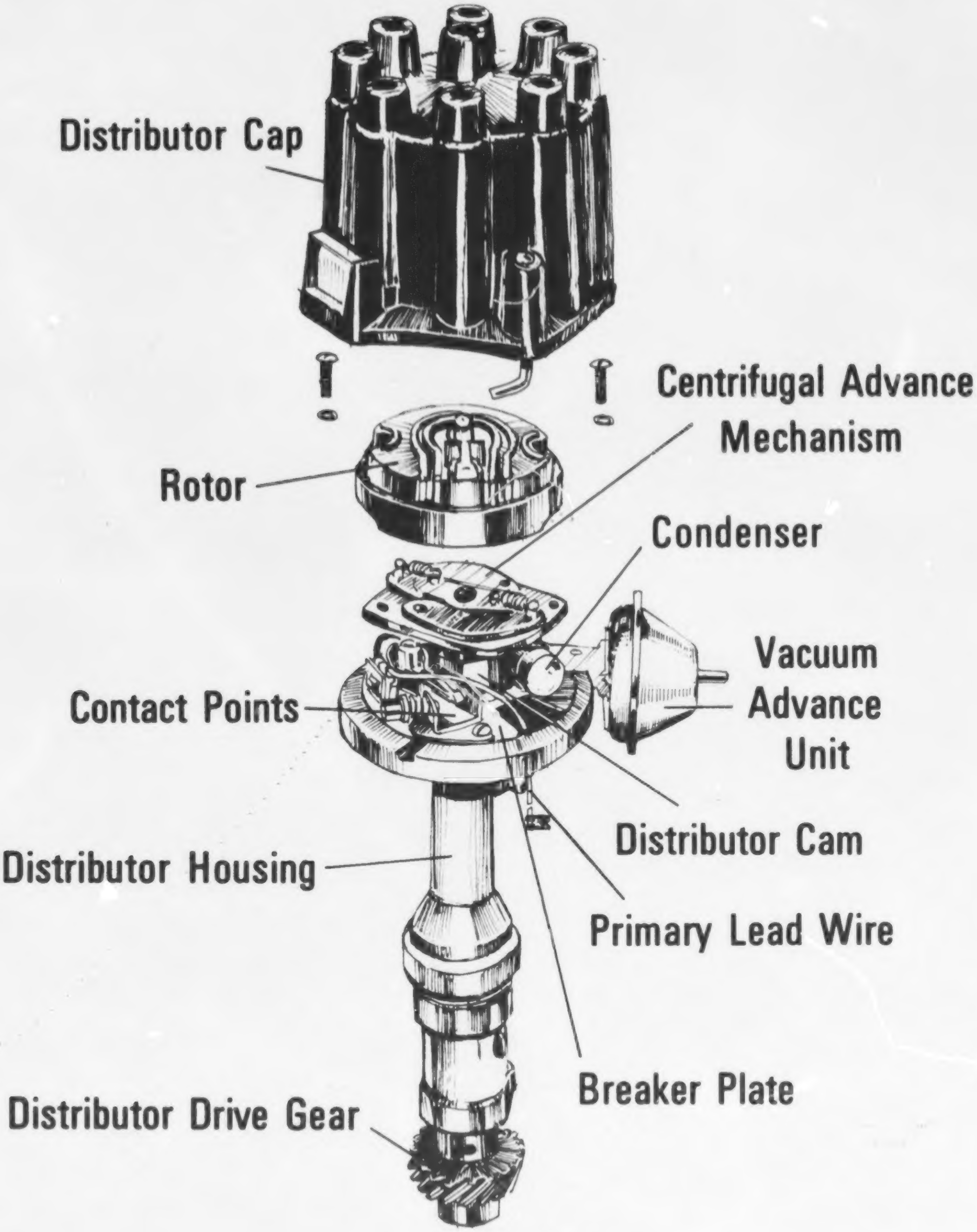
D. With the primary circuit open, the magnetic field in the coil collapses and induces a high voltage surge in the secondary circuit

(CAUTION: The ignition switch should be in the Off position when making repairs to the ignition system to prevent damage to the control unit.)

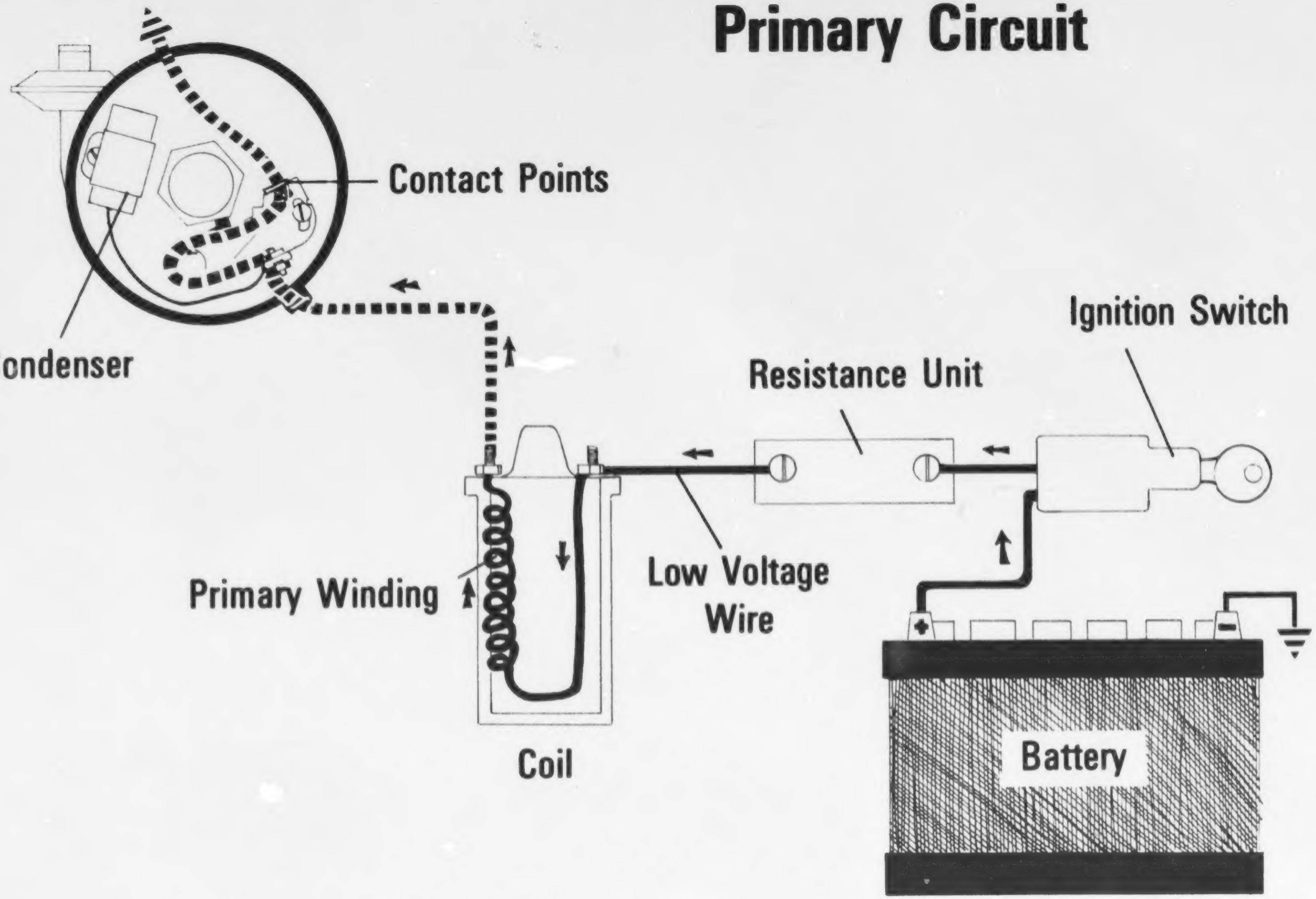
Components of the Ignition System


Spark Advance Mechanism
Condenser
Contact Points
Breaker Cam
Secondary Ignition Cable
Resistor Bypass Circuit Operates Only While Cranking Engine
Ignition Switch
Primary Resistance Unit
Rotor
Spark Plug
Distributor
Ignition Coil
Primary Ignition Wire
Distributor Cap
+
−
Battery

Distributor Components


Distributor Cap
Centrifugal Advance Mechanism
Rotor
Condenser
Vacuum Advance Unit
Contact Points
Distributor Cam
Distributor Housing
Primary Lead Wire
Breaker Plate
Distributor Drive Gear

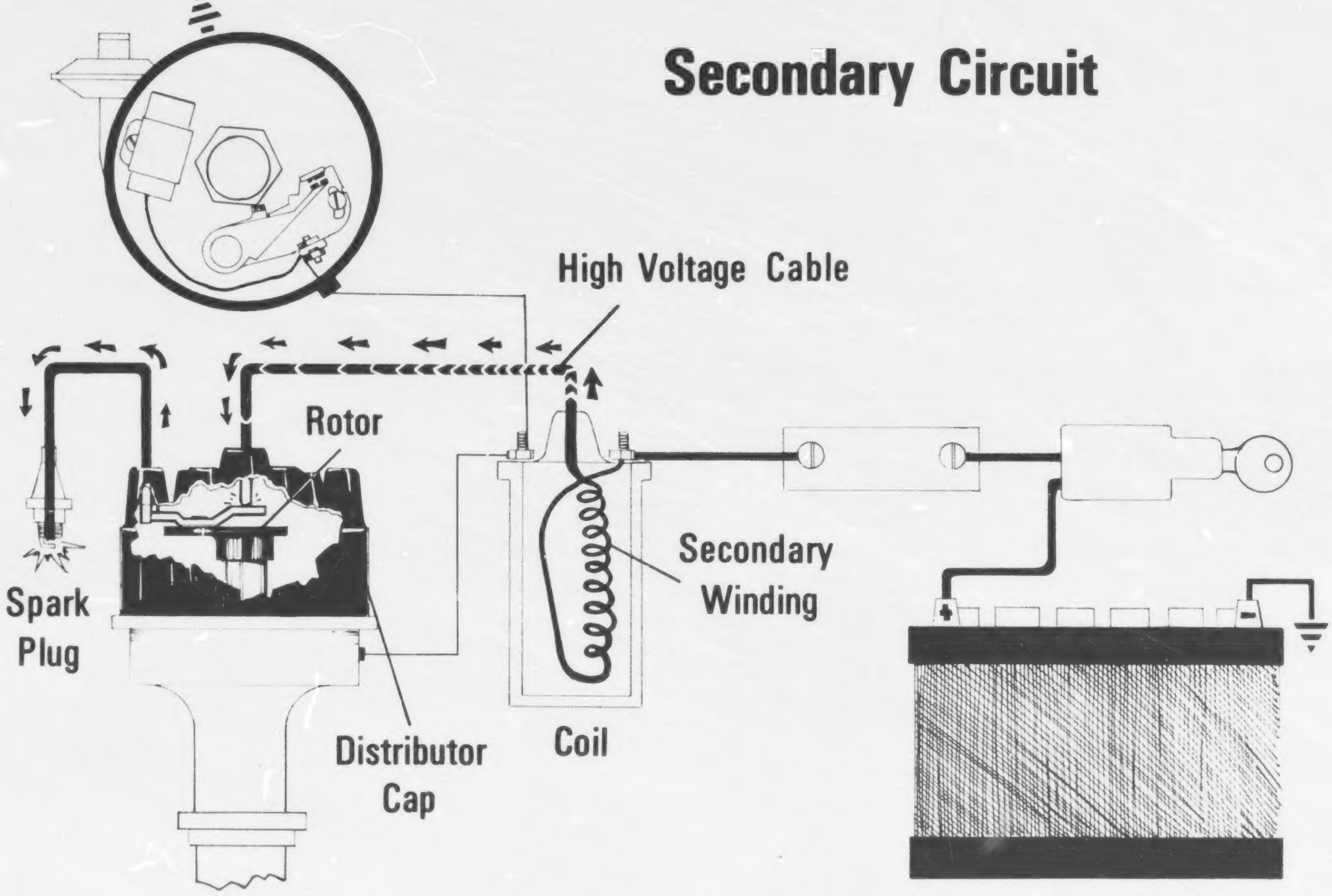
Primary Circuit


Contact Points
Condenser
Ignition Switch
Resistance Unit
Primary Winding
Low Voltage Wire
Coil
Battery
+
−

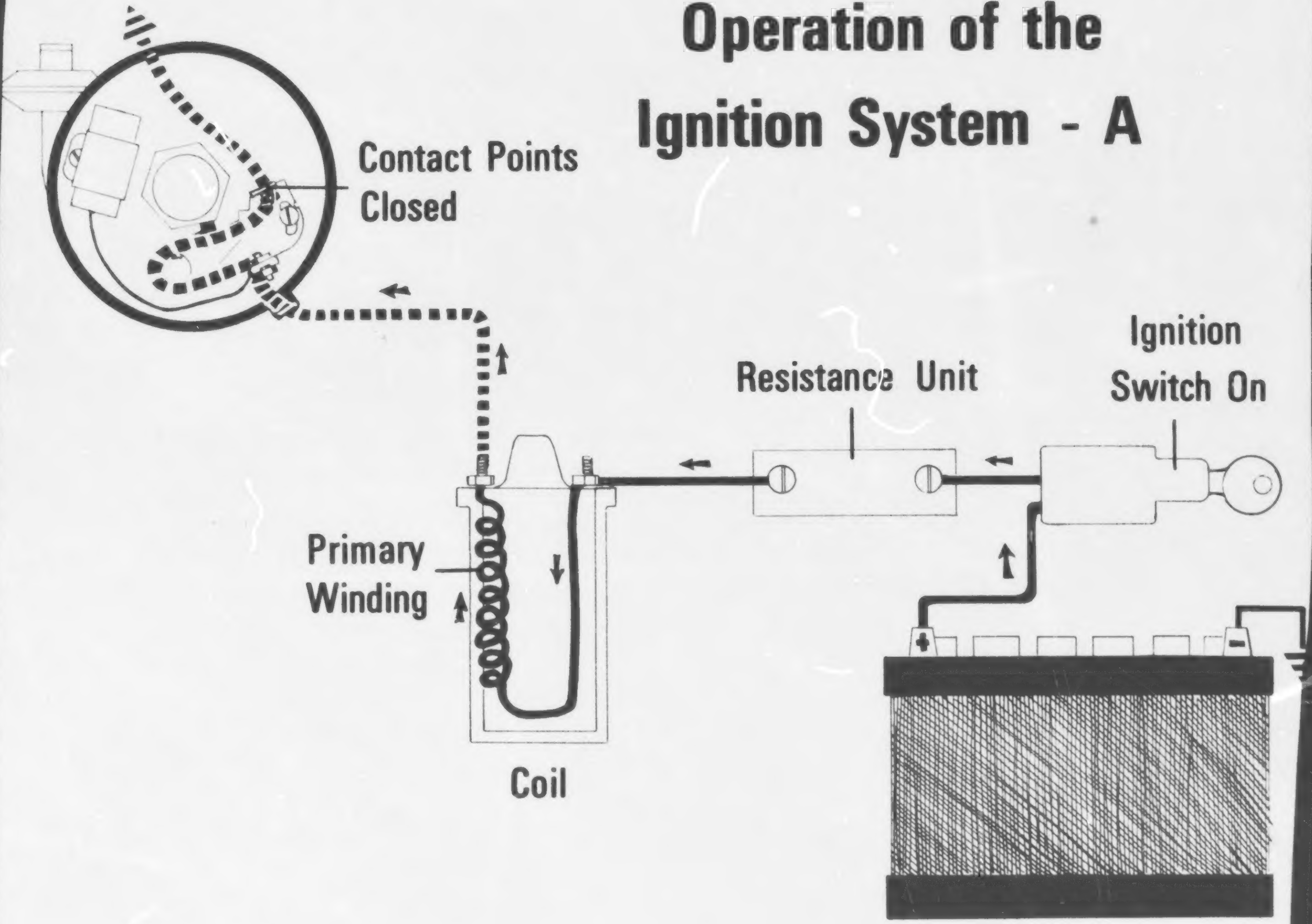
TM 3

AM II - 181-B

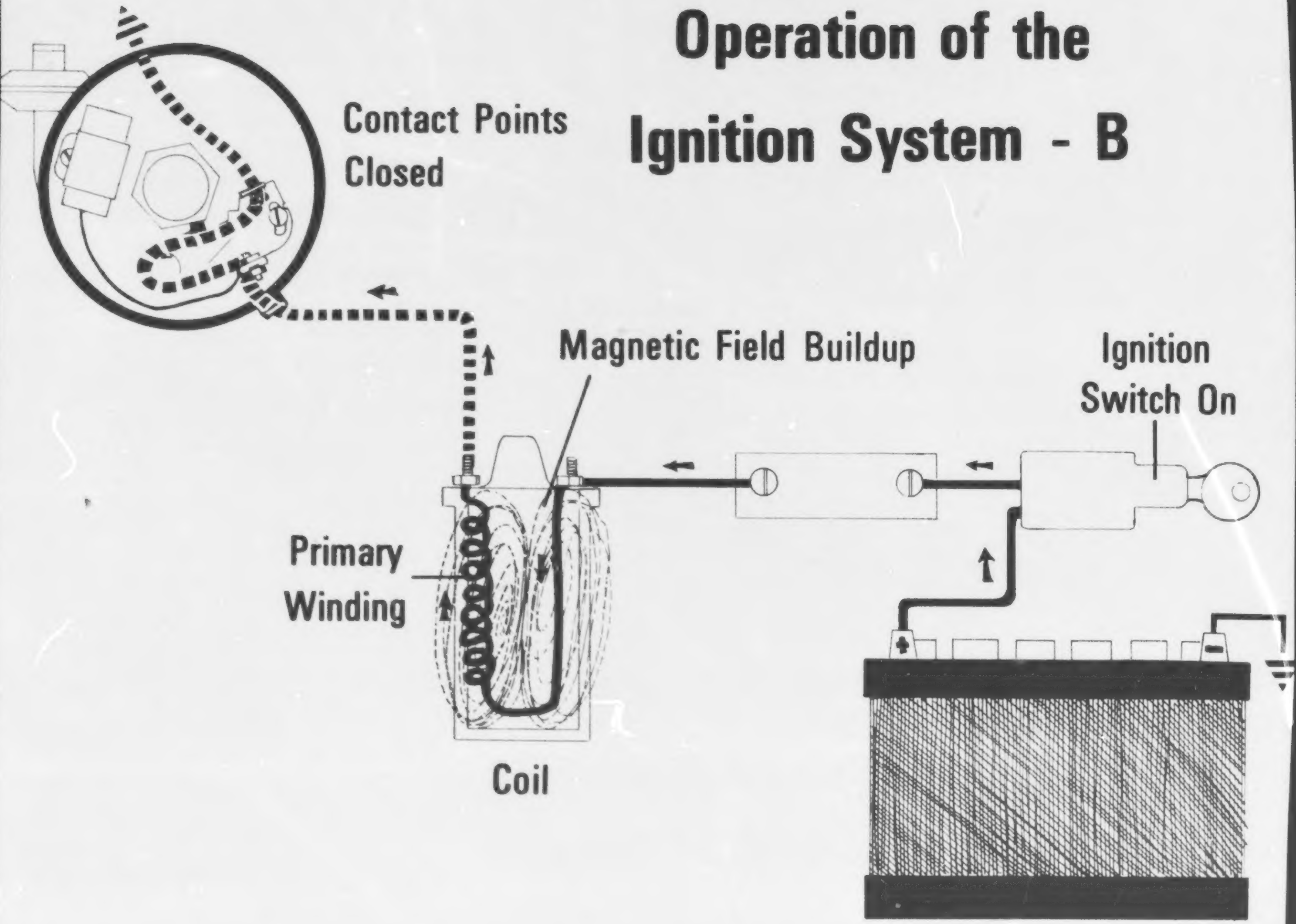
Secondary Circuit


High Voltage Cable
Rotor
Spark Plug
Distributor Cap
Coil
Secondary Winding
+
-

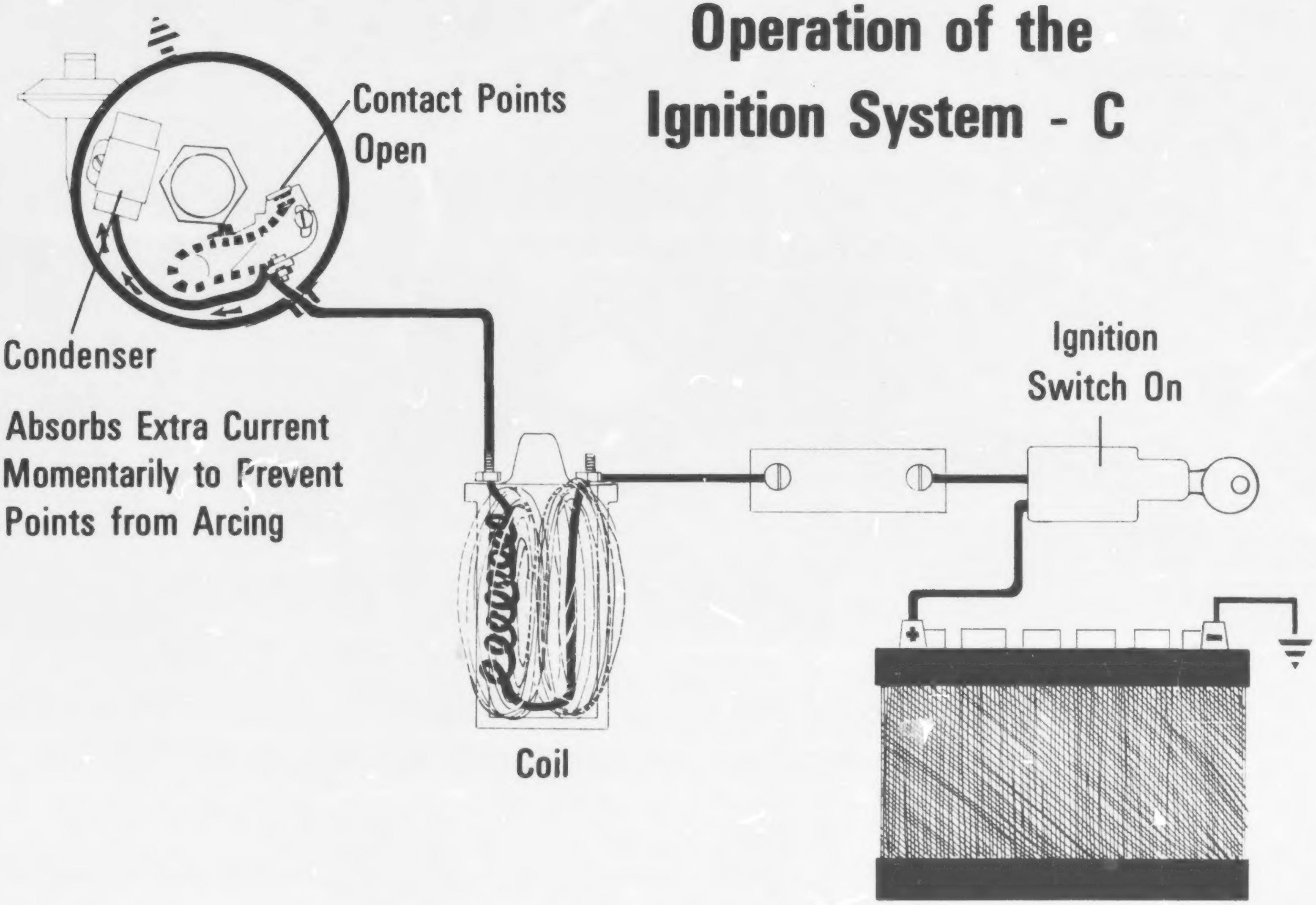
Operation of the Ignition System - A


Contact Points
Closed
Ignition
Switch On
Resistance Unit
Primary
Winding
Coil
+
-

Operation of the Ignition System - B


Contact Points Closed
Magnetic Field Buildup
Ignition Switch On
Primary Winding
Coil
+
−

Operation of the Ignition System - C



Contact Points Open

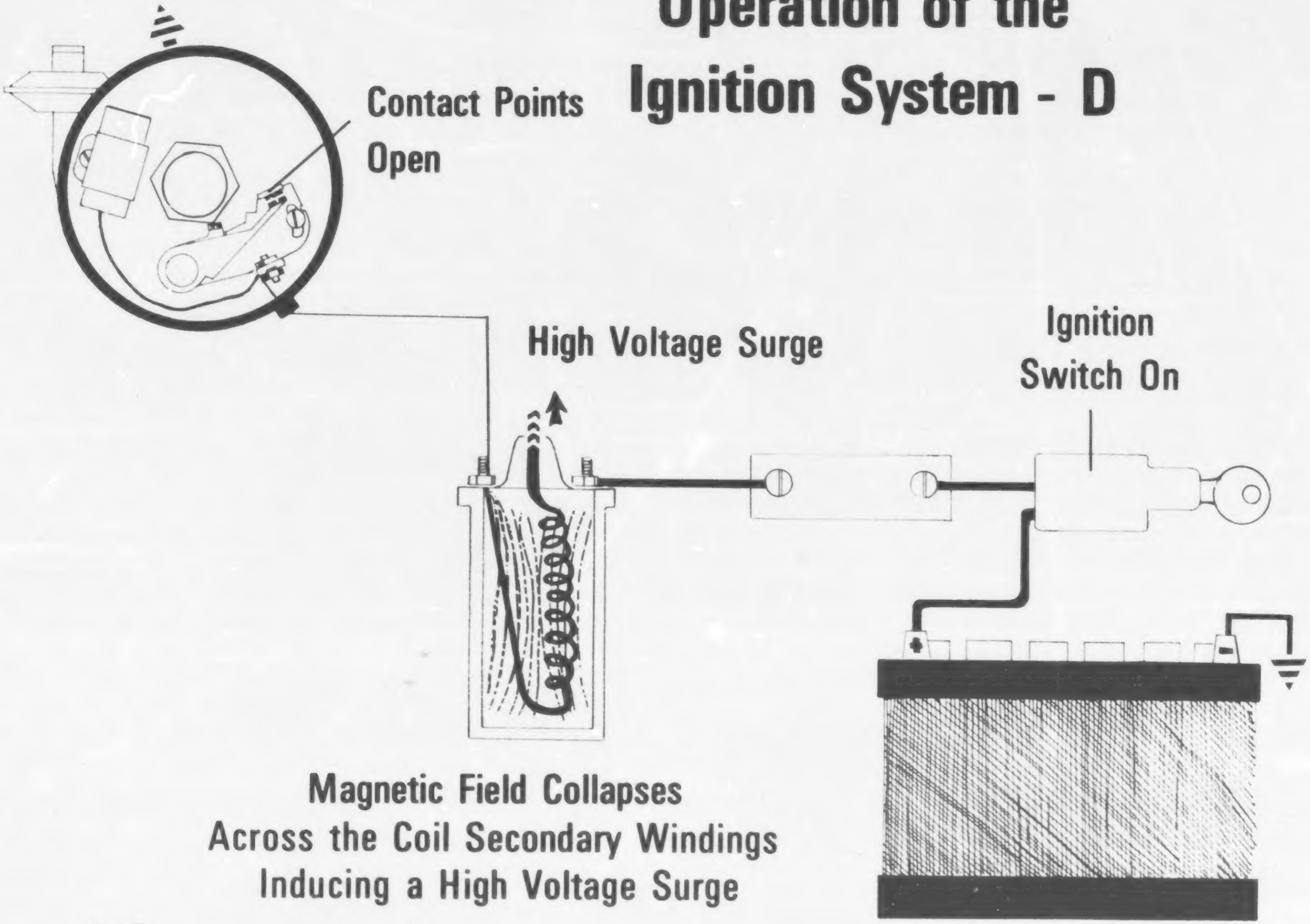
Condenser

Absorbs Extra Current Momentarily to Prevent Points from Arcing

Coil

Ignition Switch On

Operation of the Ignition System - D



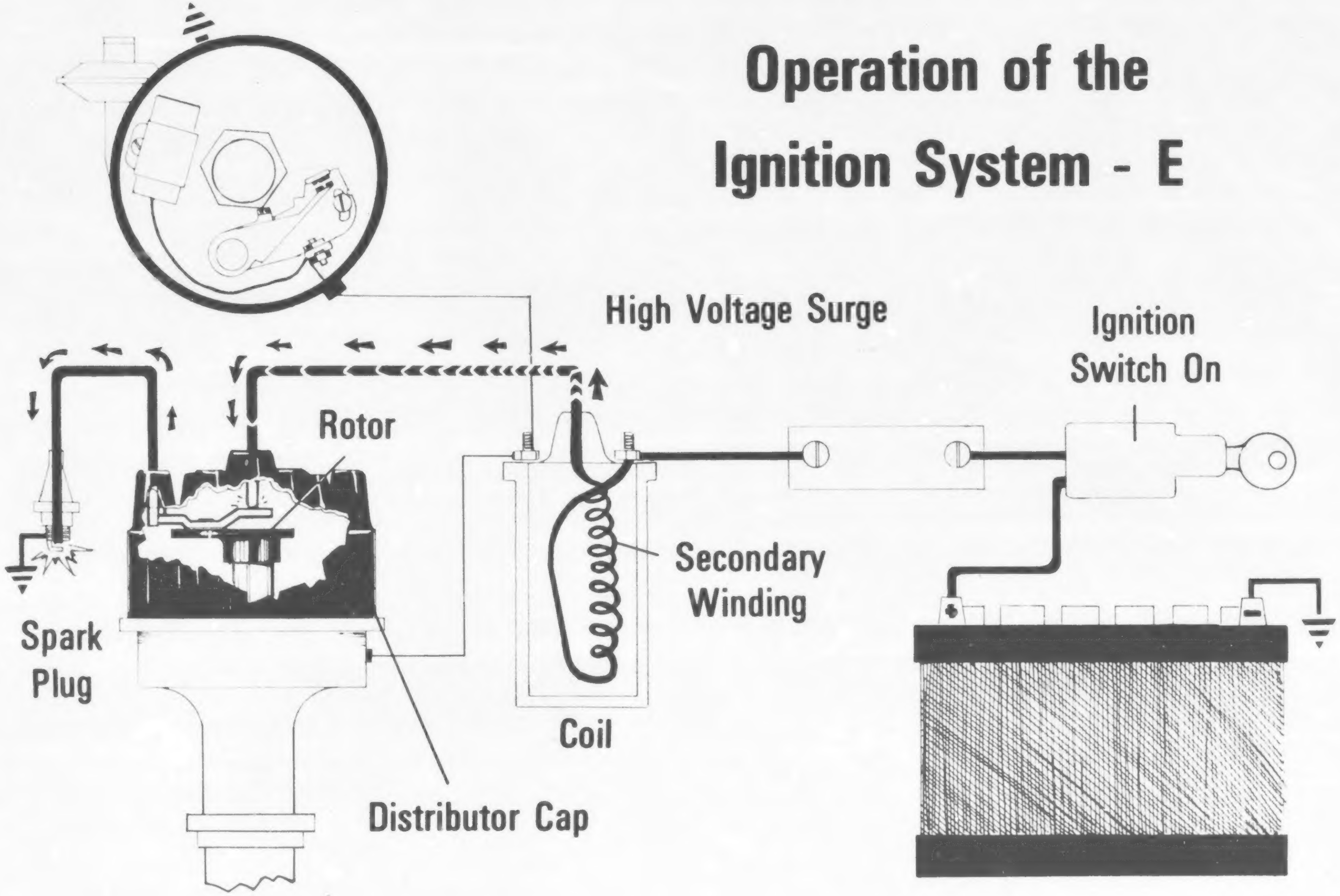
Contact Points Open

High Voltage Surge

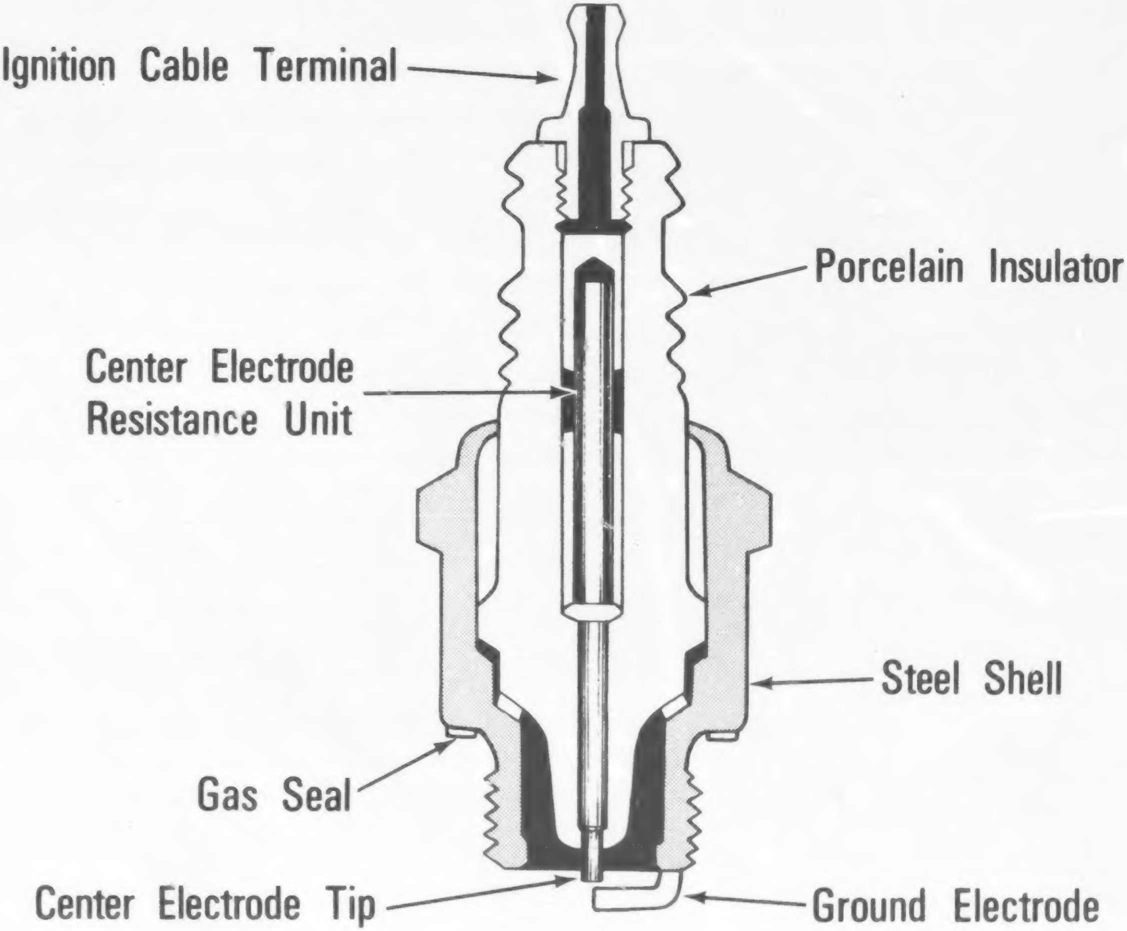
Ignition Switch On

Magnetic Field Collapses
Across the Coil Secondary Windings
Inducing a High Voltage Surge

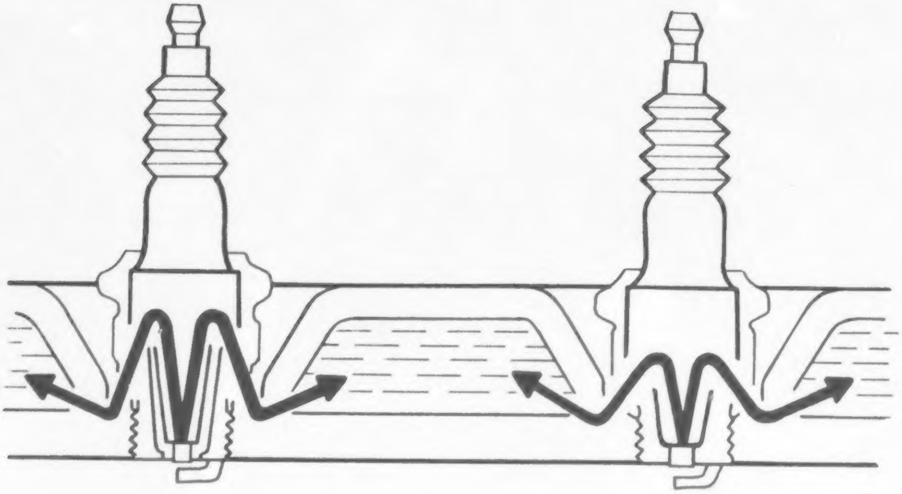
Operation of the Ignition System - E


High Voltage Surge
Ignition Switch On
Rotor
Secondary Winding
Spark Plug
Coil
Distributor Cap

Parts of a Spark Plug


Ignition Cable Terminal
Porcelain Insulator
Center Electrode Resistance Unit
Steel Shell
Gas Seal
Center Electrode Tip
Ground Electrode

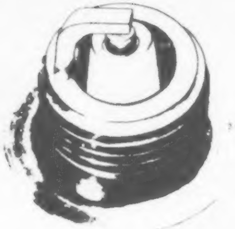
Spark Plug Heat Range



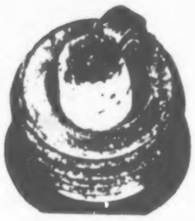
Hot Plug

Cold Plug

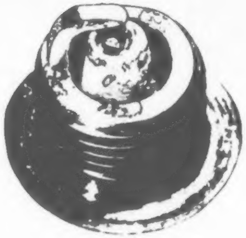
Spark Plug Conditions and Causes



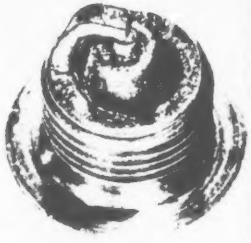
Normal



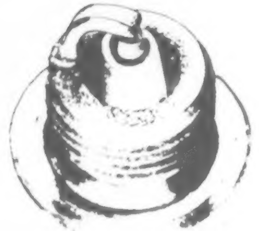
Preignition



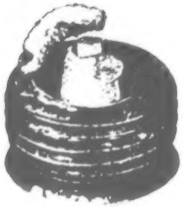
Too Hot



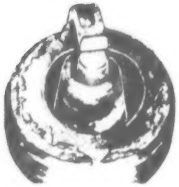
Oil Deposits



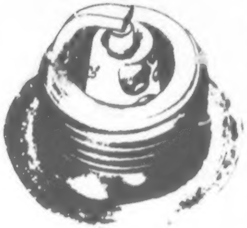
Carbon Deposits



Modifier Deposits

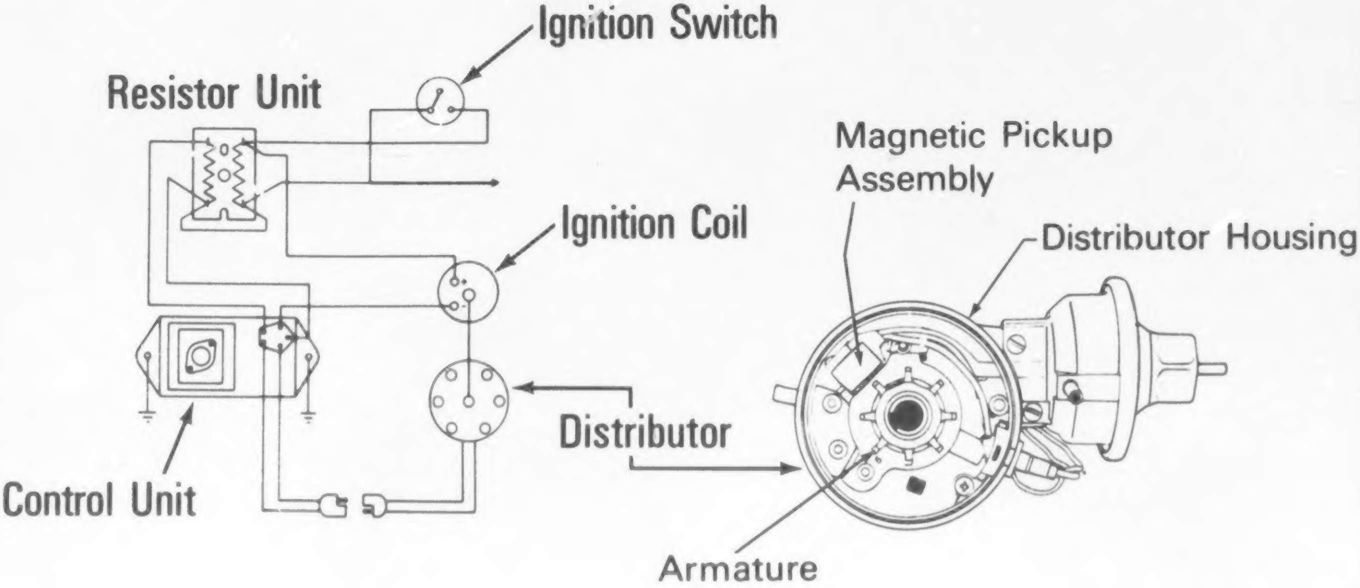


High-Speed Glazing



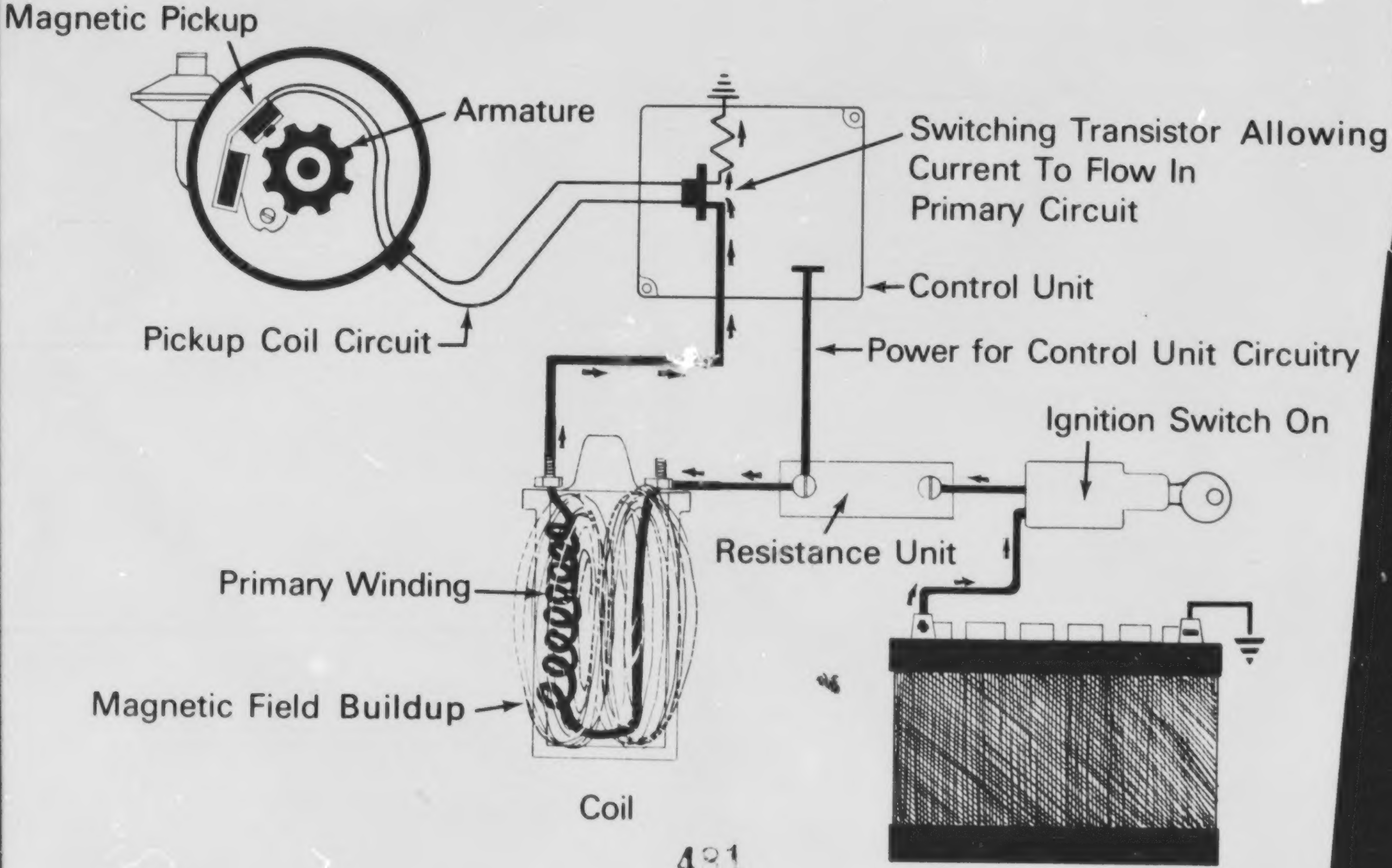
Splashed Deposits

Major Components of the Electronic Ignition System


Ignition Switch
Resistor Unit
Magnetic Pickup Assembly
Ignition Coil
Distributor Housing
Distributor
Control Unit
Armature

Operation of Electronic Ignition System

Armature Teeth Not Aligned with Pickup Coil
No Current Flow In Pickup Circuit


Magnetic Pickup
Armature
Switching Transistor Allowing Current To Flow In Primary Circuit
Control Unit
Pickup Coil Circuit
Power for Control Unit Circuitry
Ignition Switch On
Resistance Unit
Primary Winding
Magnetic Field Buildup
Coil

IGNITION SYSTEM
UNIT IV

JOB SHEET #1--CHECK AND SET IGNITION TIMING

I. Tools and equipment

A. Timing light

B. Combination end wrenches, 7/16" - 9/16" (11 mm - 15 mm)

C. Special distributor wrenches as required

D. Shop towels

E. Chalk

F. Safety glasses

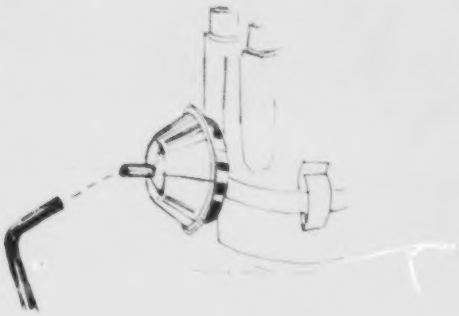
II. Procedure

A. Obtain manufacturer's specifications for ignition timing, dwell, and rpm

(NOTE: Dwell and rpm must be set to manufacturer's specifications before timing is set.)

B. Remove vacuum line at the distributor (Figure 1)

FIGURE 1



C. Locate and clean the ignition timing marks on the harmonic balancer; mark with chalk

D. Locate and clean the timing pointer or plate on the front cover

E. Connect the timing light according to the instructions for the light being used

(NOTE: Do not puncture spark plug cables with pins or clips to make connections.)

JOB SHEET #1

F. Position wires away from moving engine parts

G. Start the engine

H. Make sure the engine is idling at manufacturer's recommendations

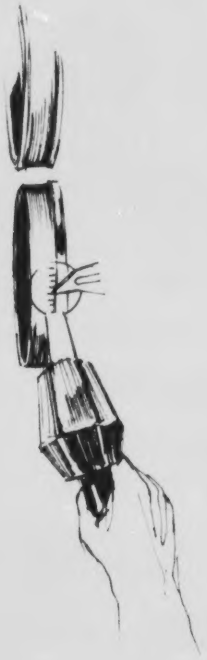
(NOTE: The engine must idle correctly to prevent incorrect timing caused by the centrifugal advance.)

I. Check ignition timing and adjust as required

1. Direct the timing light toward the timing marks (Figure 2)

(NOTE: If the timing is correct, the timing marks will line up at the check point. If the timing is incorrect, proceed as follows.)

FIGURE 2

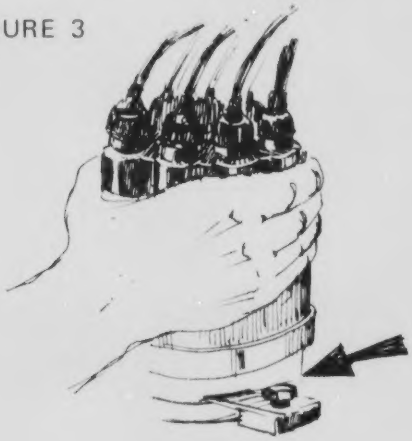


2. Loosen the clamp or lock screw on the distributor

JOB SHEET #1

3. Move the distributor until the timing marks are aligned (Figure 3)

FIGURE 3



4. Tighten the clamp or lock screw on the distributor

J. Recheck timing

K. Shut off engine

L. Disconnect timing light

(NOTE: Remove timing light adapter on spark plug if used.)

M. Replace vacuum line on distributor

IGNITION SYSTEM
UNIT IV

JOB SHEET #2--REMOVE AND REPLACE A DISTRIBUTOR

I. Tools and equipment

   A. Basic hand tool set

   B. Special distributor wrenches as required

   C. Fender cover

   D. Auxiliary starter button

   E. Safety glasses

II. Procedure

   A. Position fender cover on fender

   B. Remove air cleaner if required

   C. Remove the distributor wire from coil or distributor as required

   D. Remove the distributor cap and place out of the way

   E. Check position of the rotor

   (NOTE: It is necessary that the position be marked or indicated in some manner for re-installation.)

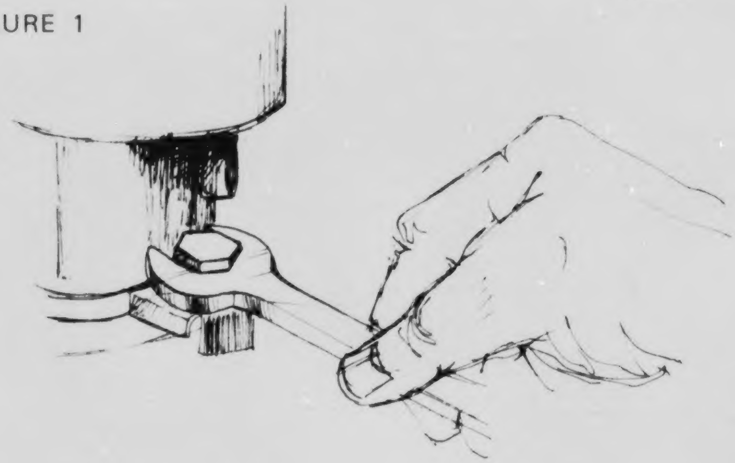
   F. Remove vacuum hose line from distributor

JOB SHEET #2

G. Remove distributor clamp screw and hold-down clamp (Figure 1)

(NOTE: Mark position of distributor to aid replacement. Blow or brush away foreign material around distributor base.)

FIGURE 1



H. Pull distributor up slowly and check direction in which the rotor turns

(NOTE: Knowing the amount the rotor turns and the direction it turns will be necessary for proper re-installation.)

I. Remove distributor from engine

(CAUTION: Avoid dropping bolts, brackets, or foreign material into opening. Cover with a shop towel.)

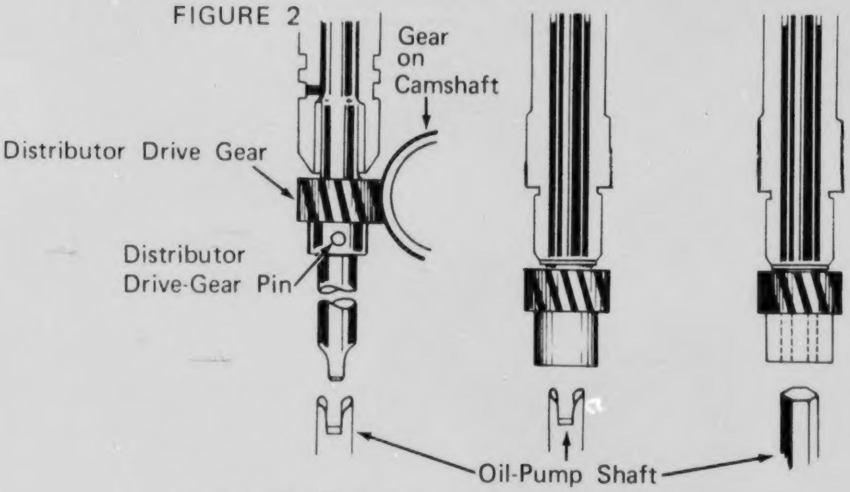
J. Service distributor as required

JOB SHEET #2

K. Install distributor in opening

(NOTE: The rotor must be pointing in the same direction as it was before removal. Occasionally, the distributor will not fall into place because the oil pump shaft has moved. The rotor should be positioned as close as possible to the beginning location and the engine should be rotated slightly until it falls into place. See Figure 2.)

FIGURE 2



L. Install hold-down clamp and clamp screw

M. Tighten the hold-down screw slightly

N. Replace vacuum lines

O. Replace distributor cap and wires if removed

P. Replace distributor lead wire

Q. Check all connections for correct placement

R. Start engine and set timing

(NOTE: If the engine was turned while the distributor was removed, it will be necessary to retime the engine. Use the following steps.)

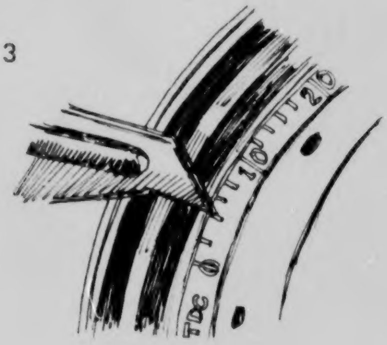
S. Set distributor basic timing

1. Remove number one cylinder spark plug
2. Install auxiliary starter button and crank the engine until compression is felt on number one cylinder

JOB SHEET #2

3. Crank the engine with short movements until the timing marks on the harmonic balancer index with the timing marks on the front cover (Figure 3)

FIGURE 3



4. Replace distributor in engine with the rotor pointing toward No. 1 spark plug wire in the distributor cap and with contact points ready to open

T. Replace all hoses, wires, and hold-down clamp

U. Replace spark plug and spark plug wire

V. Start engine

W. Set timing

IGNITION SYSTEM
UNIT IV

JOB SHEET #3--REMOVE AND REPLACE CONTACT POINTS AND CONDENSER

I. Tools and equipment

  A. Ignition wrenches

  B. Feeler gauges, 0.010" - 0.025" (0.2540 mm - 0.635 mm)

  C. Screwdrivers as required

  D. Distributor cam lubricant

  E. Shop towel

  F. Point alignment tools

  G. Spring gauge

  H. Timing light

  I. Safety glasses

II. Procedure

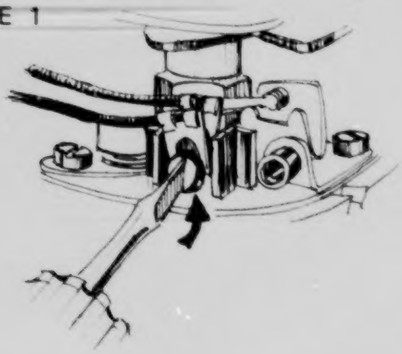
  A. Remove distributor cap and place out of the way

  B. Remove rotor

  C. Determine condition of contact points and location of wires, screws, and eccentric as used

  D. Disconnect contact point primary lead wire and condenser wire by loosening attaching screw (Figure 1)

FIGURE 1

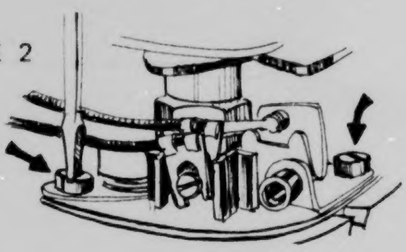


JOB SHEET #3

E. Remove screws holding contact points in place (Figure 2)

(NOTE: Some points have slotted holes that will allow points to be removed with attaching screws loosened two to three turns.)

FIGURE 2



F. Remove contact point set

G. Remove screw holding condenser in place

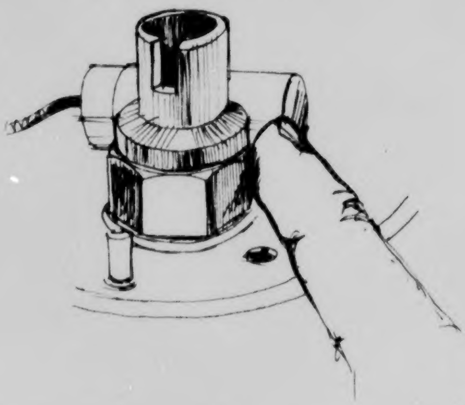
H. Remove condenser

I. Clean breaker plate and distributor cam

J. Lubricate the distributor cam with a light coat of cam lubricant (Figure 3)

(NOTE: On distributors with the centrifugal weights accessible, place a drop of light oil on each weight pivot post.)

FIGURE 3



K. Place the contact points in distributor and install attaching screws

L. Replace condenser and attaching screw; tighten securely

JOB SHEET #3

M. Replace the primary lead and condenser wires

(NOTE: Position the wires to avoid binding or grounding.)

N. Tighten primary lead and condenser wires securely

O. Check point alignment and adjust as required

P. Check contact point breaker spring tension

Q. Adjust contact point opening (Figure 4)

(NOTE: Crank the engine to position the rubbing block of the contact points on the peak of a cam lobe.)

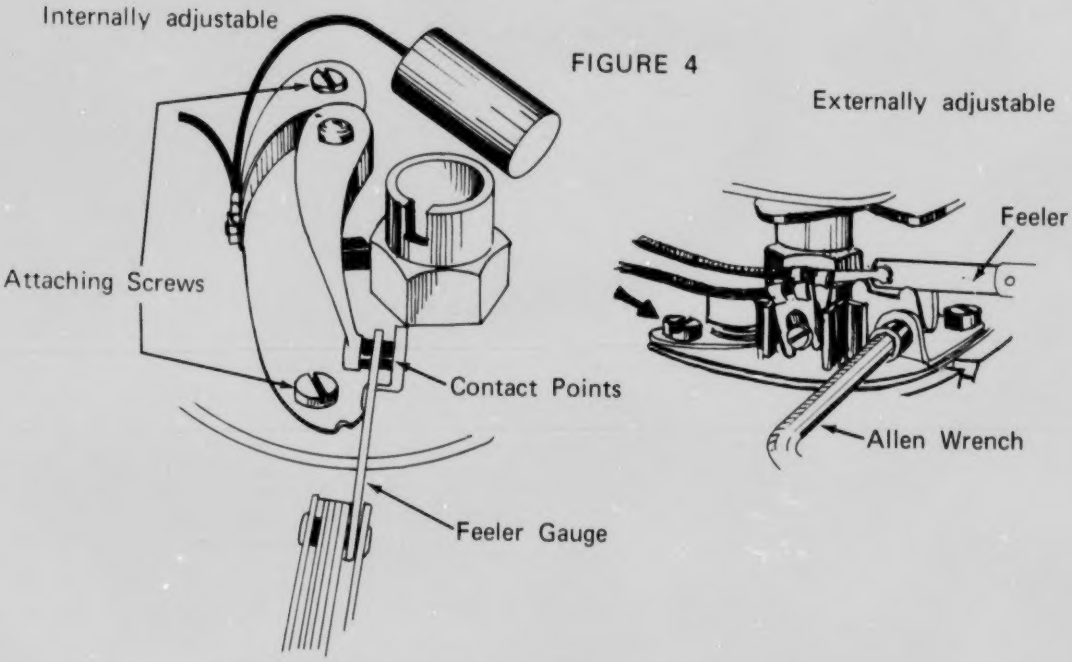


FIGURE 4

Internally adjustable

Externally adjustable

(NOTE: The externally adjustable points can be more accurately and easily set with a dwell meter while the engine is running. Refer to Job Sheet #4.)

R. Adjust contact points to manufacturer's recommendations

S. Tighten contact point attaching screws securely; recheck contact point opening

T. Install rotor

(NOTE: Make sure the rotor is positioned correctly and securely in place.)

JOB SHEET #3

U. Install distributor cap

(NOTE: Make sure the distributor is positioned correctly and is securely in place.)

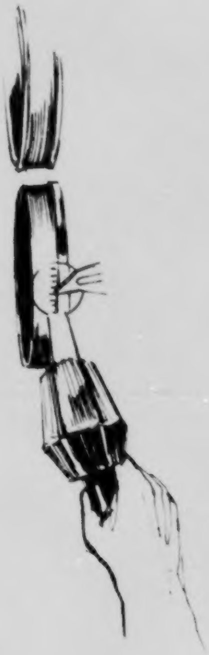
V. Replace distributor in engine if removed

W. Start engine

X. Set timing to manufacturer's specifications (Figure 5)

(NOTE: Refer to emission system decal on engine for specific specifications.)

FIGURE 5



IGNITION SYSTEM
UNIT IV

JOB SHEET #4--ADJUST DWELL ON AN EXTERNALLY ADJUSTABLE DISTRIBUTOR

I. Tools and equipment

   A. Dwell meter

   B. Hex wrench for contact point adjusting

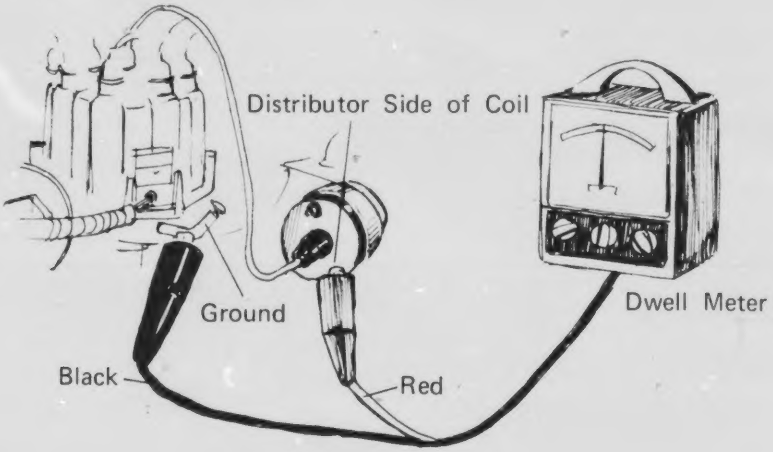
   C. Safety glasses

II. Procedure

   A. Hook up dwell meter

   (NOTE: Observe correct hookup procedures and position wires away from moving engine parts. See Figure 1.)

   FIGURE 1


Distributor Side of Coil
Dwell Meter
Ground
Black
Red

   B. Refer to manufacturer's specifications for desired dwell setting

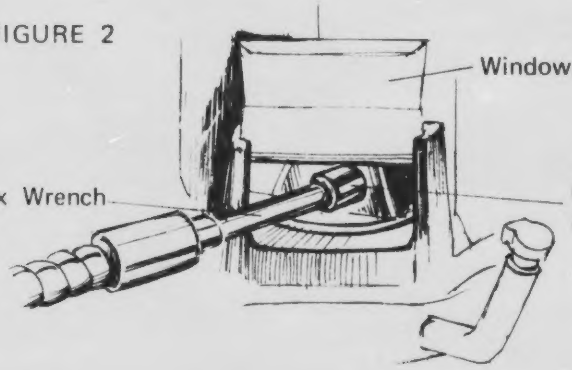
   C. Start the engine

   D. Raise distributor cap adjustment window

JOB SHEET #4

E. Insert hex wrench into contact point adjustment screw (Figure 2)

FIGURE 2


Window
Hex Wrench
Contact Point Adjusting Screw

F. Adjust contact point dwell while observing dwell meter reading to comply with manufacturer's specifications

G. Remove hex wrench and recheck dwell reading

H. Shut off the engine

I. Remove dwell meter

J. Push window on distributor cap down securely

IGNITION SYSTEM
UNIT IV

JOB SHEET #5--TEST AND ADJUST DISTRIBUTOR ON DISTRIBUTOR TESTER

I. Tools and equipment

- A. Distributor tester
- B. Distributor without cap
- C. Screwdriver set
- D. Ignition wrench set
- E. Cam lubricant
- F. Light motor oil

II. Procedure

A. Inspect the distributor visually for the following conditions

1. Shaft end play
2. Distributor drive for wear or damage
3. Shaft and bearings for wear
4. Breaker plate for smooth operation and excessive looseness
5. Insulators and lead wires for damage or wear

B. Mount distributor in tester (Figure 1)

1. Raise clamp arms high enough to permit the distributor shaft to clear the drive chuck
2. Position distributor in clamp with the vacuum chamber to the right side and tighten the clamp on the distributor case

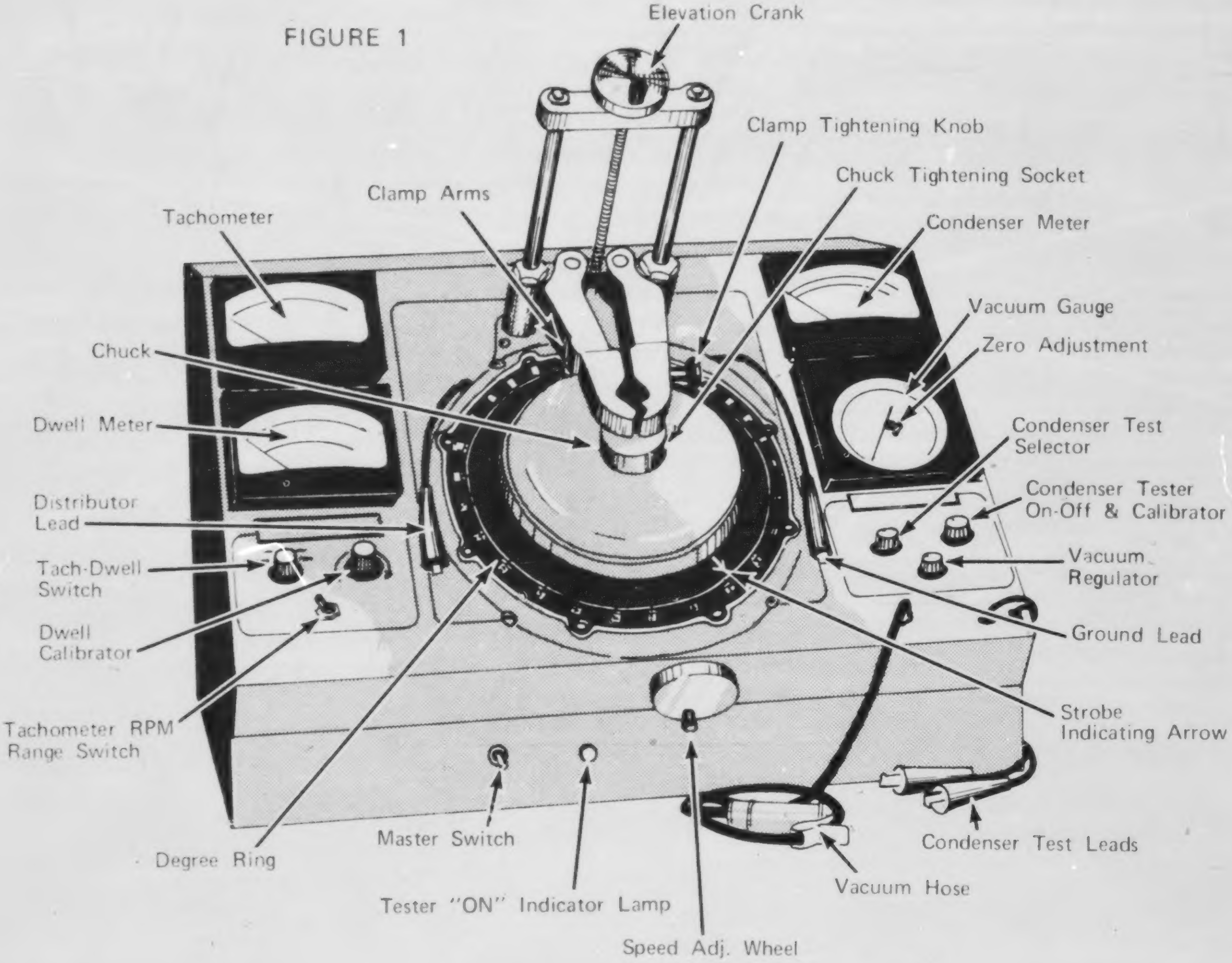
   (NOTE: The distributor should be mounted so that it aligns well with the drive chuck and the shaft is free to turn.)

JOB SHEET #5

3. Lower the shaft into the drive chuck and tighten the chuck

   (NOTE: The distributor shaft should be approximately centered from top to bottom in the drive chuck.)

FIGURE 1


Elevation Crank
Clamp Tightening Knob
Chuck Tightening Socket
Clamp Arms
Tachometer
Condenser Meter
Vacuum Gauge
Zero Adjustment
Chuck
Dwell Meter
Condenser Test Selector
Condenser Tester On-Off & Calibrator
Distributor Lead
Tach-Dwell Switch
Vacuum Regulator
Dwell Calibrator
Ground Lead
Tachometer RPM Range Switch
Strobe Indicating Arrow
Master Switch
Degree Ring
Condenser Test Leads
Vacuum Hose
Tester "ON" Indicator Lamp
Speed Adj. Wheel

C. Test the condenser

1. Set drive switch in the position for the direction of rotation of the distributor

2. Set speed to "0" rpm

3. Connect condenser test leads together

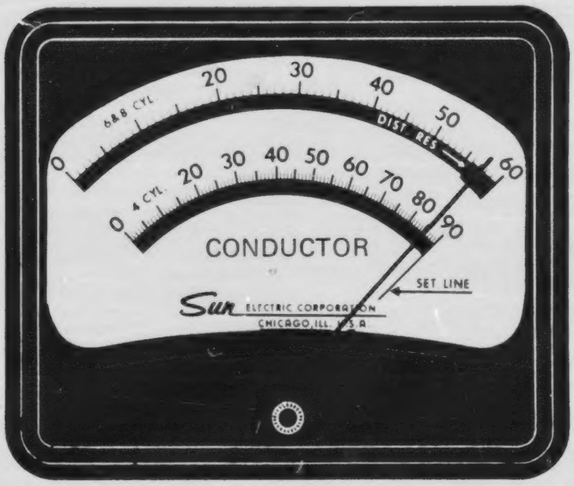
JOB SHEET #5

4. Set condenser test selector switch in series resistance position and allow to warm up for approximately 30 seconds (Figure 2)

5. Rotate distributor shaft until cam holds breaker points open

6. Adjust the calibration control until the meter reads on set line (Figure 2)

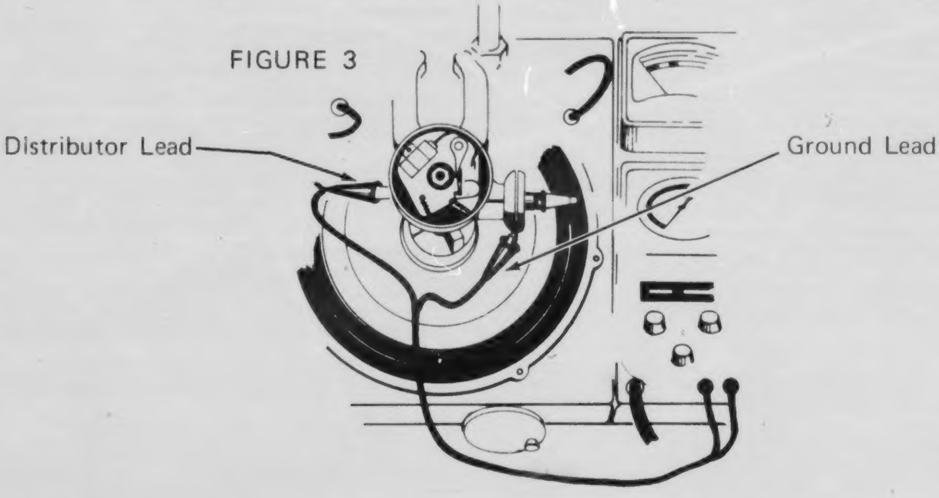
FIGURE 2


0
6&8 CYL
20
30
40
50
DIST. RES
60
0
4 CYL.
20
30
40
50
60
70
80
90
CONDUCTOR
SET LINE
Sun ELECTRIC CORPORATION
CHICAGO, ILL. U.S.A.

7. Separate leads and connect one to the distributor primary lead and the other to the distributor case (Figure 3)

8. Rotate distributor shaft until cam holds breaker points open

FIGURE 3


Distributor Lead
Ground Lead

JOB SHEET #5

9. Test series resistance with test selector switch in that position

   (NOTE: The meter should read in the black bar at the right end of scale.)

10. Test condenser capacity with test selector switch in the capacity position

    (NOTE: Compare with manufacturer's specifications.)

11. Test condenser leakage with selector switch in the leakage position

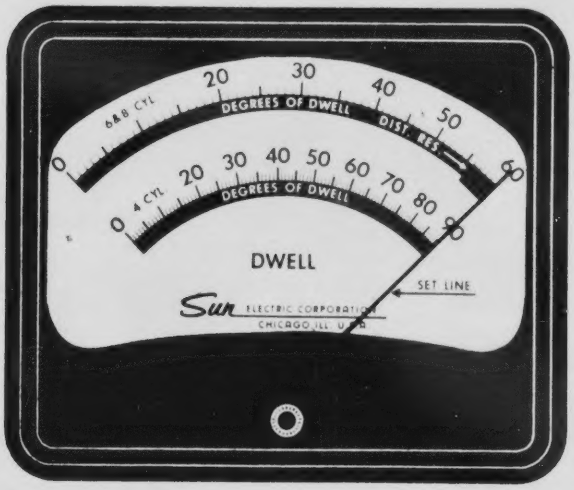
    (NOTE: The meter should read in the black bar at the left end of scale.)

12. Set test selector to series resistance position and turn condenser calibration to Off before disconnecting test leads

D. Test distributor resistance

1. Position motor switch in the proper distributor rotation with the speed control set to "0" rpm
2. Connect tester leads
3. Set tach-dwell selector switch to calibrate position and adjust dwell regulator until dwell meter reads on the set line (Figure 4)

FIGURE 4

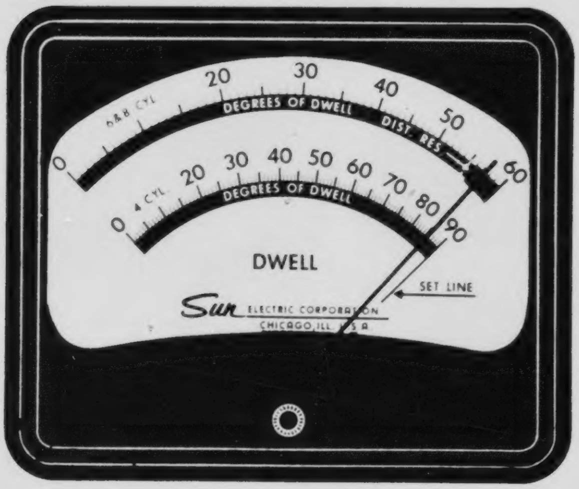

0
6&8 CYL
20
30
40
50
60
DEGREES OF DWELL
DIST. RES.
0
4 CYL
20
30
40
50
60
70
80
90
DEGREES OF DWELL
DWELL
SET LINE
Sun ELECTRIC CORPORATION
CHICAGO ILL. U.S.A.

4. Separate leads and connect distributor lead to distributor primary terminal and ground lead to distributor body

5. Close breaker points

   (NOTE: Dwell meter pointer should read within range of black bar at end of scale. A dwell meter pointer reading out of the black bar indicates excessive resistance in the distributor primary circuit. For distributors with two sets of breaker points, test the resistance of each set separately by holding one set open while testing the other. See Figure 5.)

FIGURE 5


0
6&8 CYL
20
30
40
50
60
DEGREES OF DWELL
DIST. RES
0
4 CYL
20
30
40
50
60
70
80
90
DEGREES OF DWELL
DWELL
SET LINE
Sun ELECTRIC CORPORATION
CHICAGO, ILL. U.S.A.

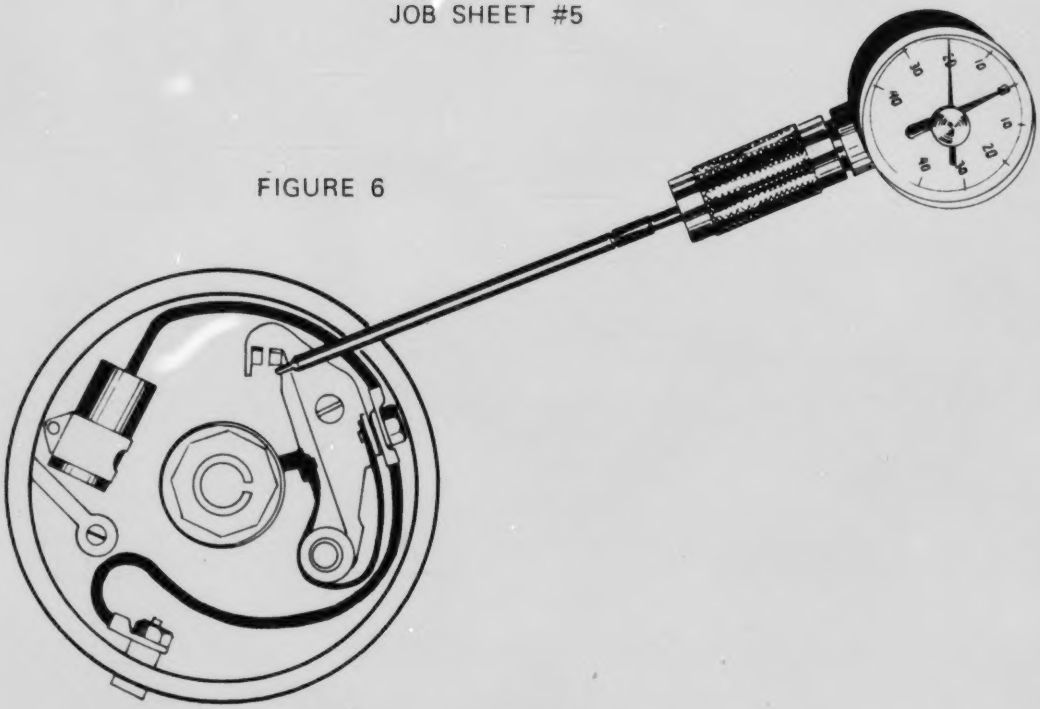
E. Test breaker point spring tension

   (NOTE: The dwell meter should be calibrated and test leads connected as for distributor resistance test.)

   1. Position the hook of the spring tension gauge near the contact of the movable breaker point (Figure 6)

JOB SHEET #5

FIGURE 6



2. Pull spring tension gauge slowly at right angles to point lever

3. Note reading on spring tension gauge at the exact time the points open, as indicated by the dwell meter reading which will fall to "0"

4. Hold the points open to approximately the normal gap with the spring tension gauge and slowly let them close

   (NOTE: The gauge reading should not decree noticeably from previous reading before the points close. If the reading does decrease noticeably, the breaker point pivot requires lubrication or replacement. Duel point distributors must have one set blocked open while testing the other set.)

F. Test cam lobe accuracy

1. Connect test leads to distributor lead and distributor body

2. Turn tach-dwell switch to position corresponding with the number of cylinder of the engine which the distributor fits

3. Adjust distributor speed to 1,000 rpm

JOB SHEET #5

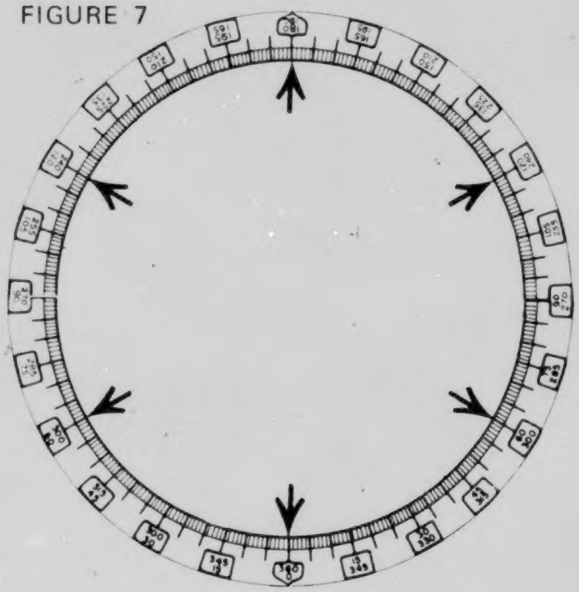
4. Rotate degree ring of tester until the "0" on the ring is aligned with one of the arrow flashes

5. Observe the position of all flashing arrows

   (NOTE: All arrow flashes should be evenly spaced around the degree ring within ±1 degree. See Figure 7.)

   90° apart on 4 lobe cams
   60° apart on 6 lobe cams
   45° apart on 8 lobe cams

FIGURE 7



G. Test breaker point alignment

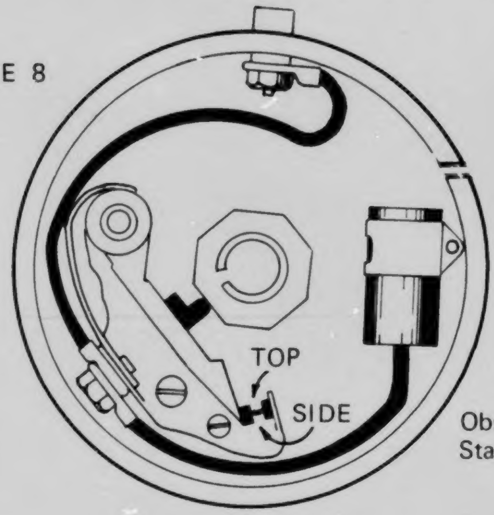
(NOTE: The tester will be set up the same as for the previous test.)

1. Observe the slight arc appearing between the breaker points

   (NOTE: The points are properly aligned when the arc appears in the center of the contacts when observed from above and from the side. See Figure 8.)

JOB SHEET #5

FIGURE 8



Observe and Bend State Stationary Point To Align

Center Arc On Point

2. Reduce distributor speed to 200 rpm

3. Align breaker points with the special bending tool

H. Adjust breaker point dwell

1. Observe dwell meter and compare reading with specifications

2. Adjust dwell by moving the stationary point toward or away from the distributor cam

   (NOTE: On duel point distributors one point set will have to be isolated while setting the other with a piece of clean fiber.)

I. Test breaker point dwell variation

1. Observe dwell meter readings while varying the distributor speed from 200 to 1,750 rpm

   (NOTE: Dwell variation in excess of 2 degrees indicates worn distributor shaft or bushings.)

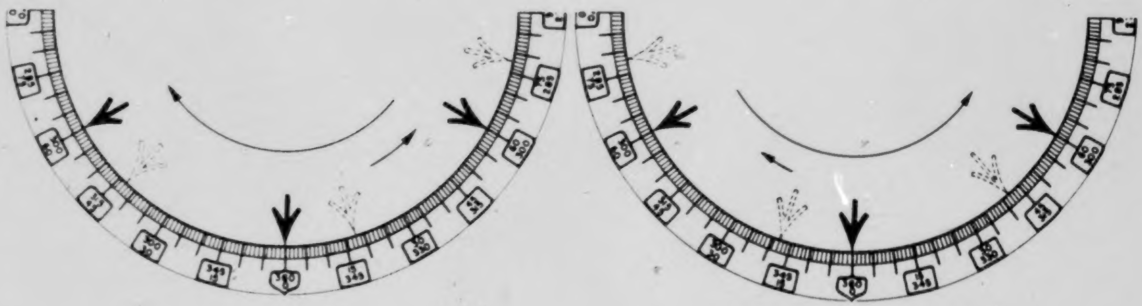
JOB SHEET #5

J. Test centrifugal advance calibration

(NOTE: This test is made to determine if the ignition timing conforms to the manufacturer's specified advance curve at all engine operating speeds.)

1. Set up tester as for the cam lobe accuracy test
2. Set speed to 200 rpm
3. Set degree ring "0" to its nearest flashing arrow
4. Increase distributor speed to each consecutive speed and note the amount of advance for each (Figure 9)

FIGURE 9



(NOTE: The amount of advance should be within ±1° of specifications if no range is given.)

5. Exceed the highest specified speed given, momentarily, then reduce distributor speed to "0" while noting the advance for each specified speed as a second test

(NOTE: If advance is excessive, the governor weight springs are weak or the wrong springs are installed. If advance is slow on acceleration and excessive on deceleration, the governor weights are sticking. If advance is insufficient both on acceleration and deceleration, governor weight spring tension is excessive.)

JOB SHEET #5

K. Test vacuum chamber diaphragm for leak

1. Attach vacuum test hose to vacuum unit

2. Seal hose with shut-off clamp

3. Adjust vacuum regulator until meter reads 15 inches

4. Release hose clamp and observe meter

(NOTE: If the meter reading momentarily falls to a lower reading and then returns to 15 inches within a few seconds, it indicates the chamber is air tight.)

L. Test vacuum controlled breaker plate

(NOTE: The breaker plate should be smooth and even in travel to maintain proper dwell and timing advance.)

1. Adjust speed control to 1,000 rpm

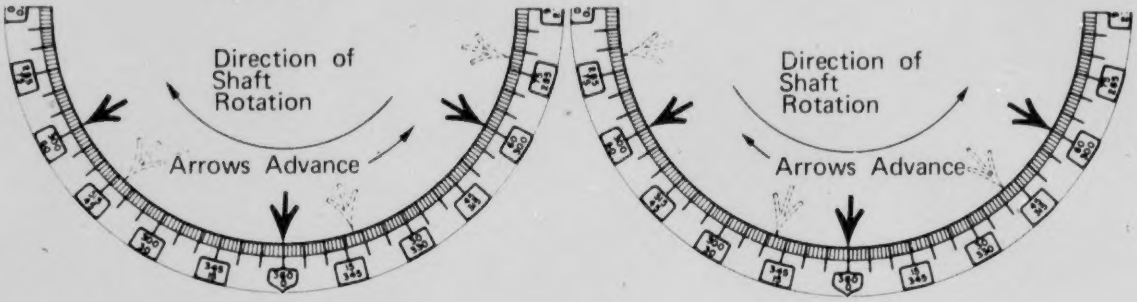
2. Adjust vacuum regulator to "0"; increase vacuum to 20 inches while watching the dwell meter pointer for variations

(NOTE: On center pivot breaker plates, variation should not exceed two degrees. On side pivot breaker plates, the dwell will vary more than two degrees but not over ten degrees. The plate should twist evenly through its full travel and remain stable.)

M. Test vacuum spark advance

1. Set the "0" of the degree ring in line with one of the arrows with no vacuum applied (Figure 10)

FIGURE 10



JOB SHEET #5

2. Adjust vacuum regulator to apply proper amount of vacuum for each specified check point and note the amount of advance obtained

3. Exceed, momentarily, the highest vacuum value specified; reduce vacuum and again note advance obtained at each specified checkpoint

   (NOTE: If advance is excessive during both steps 2 and 3, a weak advance spring is indicated. If advance is insufficient during steps 2 and 3, an excessively strong advance spring is indicated. If advance is insufficient in step 2 and excessive in step 3 or is erratic in both steps, the distributor plate is sticking or binding.)

N. Test breaker plate spring tension

1. Remove the vacuum advance unit from the distributor

2. Hook the spring tension scale on the breaker plate where the advance unit push rod was attached (Figure 11)

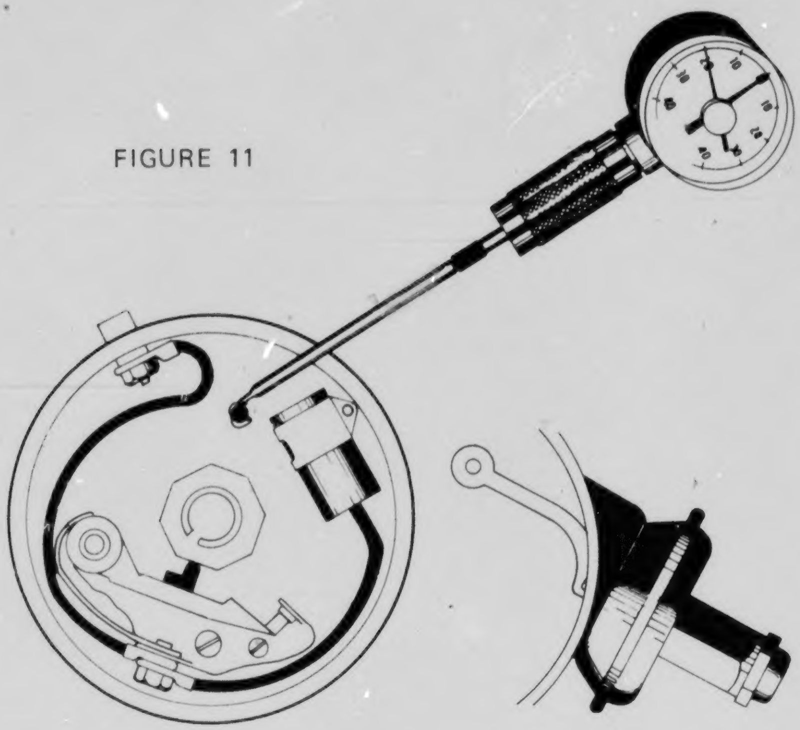


FIGURE 11

JOB SHEET #5

3. Note the amount of pull necessary to start movement of the breaker plate from the fully retarded position

   (NOTE: Refer to manufacturer's specifications for the maximum amount of pull allowed.)

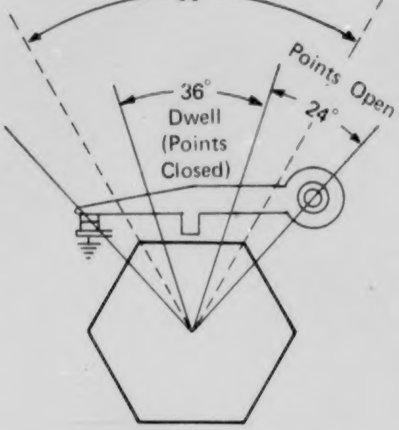
O. Adjust breaker point gap or dwell angle

1. Loosen breaker point retainer screws enough to allow the points to be moved, yet they will still maintain their positions while in operation

   (NOTE: Some points are adjusted by a screw positioned between the stationary point and the assembly base so the attaching screws will remain tight.)

2. Increase the open gap between the breaker point to reduce the dwell reading and decrease the open gap between the breaker points to increase the dwell reading (Figure 12)

FIGURE 12



Dotted Lines Indicate The 60° Between
Cam Lobes Alloted To The Firing
Of Each Cylinder Of A 6 Cylinder Engine

6 Cylinder Cam

IGNITION SYSTEM
UNIT IV

JOB SHEET #6--REMOVE, INSPECT, SERVICE, AND REPLACE SPARK PLUGS

I. Tools and equipment

   A. Spark plug socket, 3/8" drive

   B. Ratchet, 3/8" drive

   C. Extensions; 3", 6", and 10" (76 mm, 152 mm, and 250 mm), 3/8" drive

   D. Spark plug cleaner

   E. Wire brush

   F. Small point file

   G. Shop towels

   H. Plug gauge

   I. Safety glasses

   J. Fender cover

II. Procedure

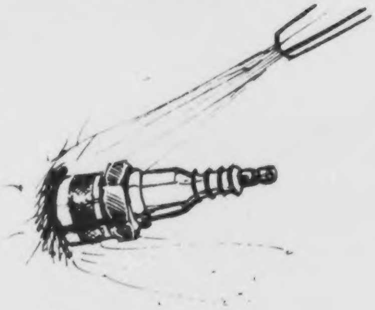
   A. Remove spark plug wires

   (NOTE: Pull the wire from the spark plug by grasping the terminal, not by pulling on the wire.)

   B. Loosen the spark plugs

   C. Clean the area around the spark plug by blowing, wiping, or brushing (Figure 1)

FIGURE 1



JOB SHEET #6

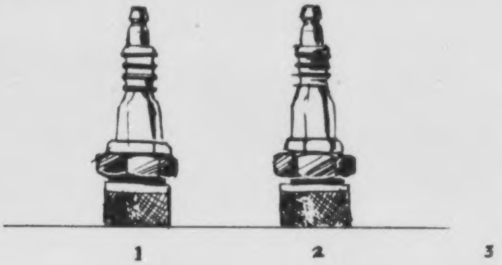
(NOTE: Loosen the spark plug approximately two turns and crank the engine so that the compression going past the spark plug threads will clean the dirt and grit from the plug seat area.)

(CAUTION: Protect your eyes when using compressed air.)

D. Remove the spark plugs

(NOTE: Arrange the spark plugs in order as they are removed. The condition of the spark plug can tell a lot about the operation of a particular cylinder. See Figure 2.)

FIGURE 2

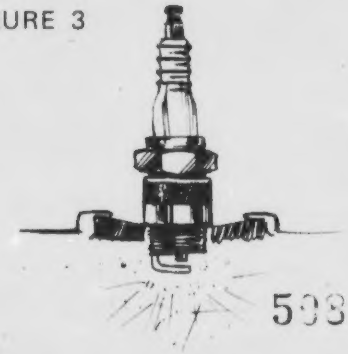


E. Remove the spark plug gaskets if required

F. Determine the condition of the spark plugs and decide whether to replace or service them

G. Clean the spark plugs on a spark plug cleaning machine (Figure 3)

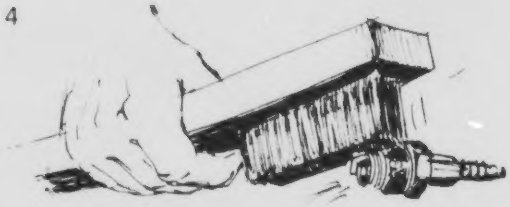
FIGURE 3



JOB SHEET #6

H. Clean the threads with a wire hand brush (Figure 4)

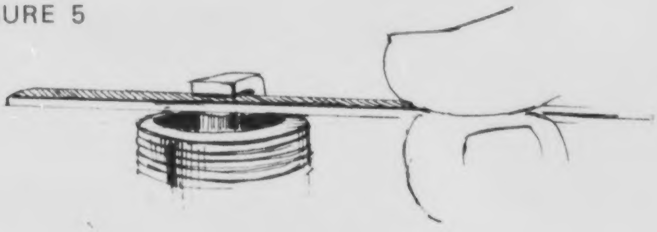
FIGURE 4



I. Bend the ground electrode slightly to open gap

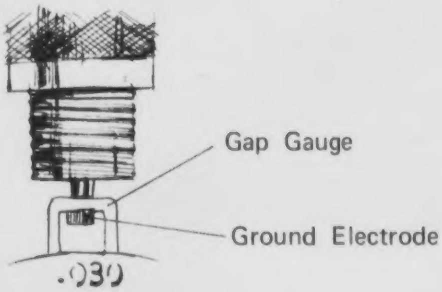
J. File the center electrode to flatten the surface and square up the edges (Figure 5)

FIGURE 5



K. Reset the gaps of new and serviced spark plugs to manufacturer's specifications (Figure 6)

FIGURE 6



(NOTE: Use a wire gauge to check the gap. Make sure the electrode surfaces are parallel.)

(CAUTION: Bend only the ground electrode.)

JOB SHEET #6

L. Install new spark plug gaskets as required

M. Install spark plugs and tighten

(NOTE: Use caution when starting the spark plugs to avoid cross-threading.)

N. Torque the spark plugs to manufacturer's recommendations

(CAUTION: Care should be taken not to overtorque spark plugs with tapered sealing surfaces because the plugs will be damaged.)

O. Replace the spark plug wires in the proper order

(NOTE: Push the spark plug wires securely into place and make sure they are in the brackets or holders.)

IGNITION SYSTEM
UNIT IV

TEST

NAME ______________________________ SCORE ____________________

1. Match the terms on the right to the correct definitions.

______a. Number of degrees of distributor cam rotation that the ignition points are closed

______b. Igniting the fuel-air mixture at the exact instant that will enable the engine to develop maximum power

______c. Low voltage circuit which energizes the ignition coil

______d. Ignition system using a control unit and magnetic pickup to open and close the primary circuit

______e. Auxiliary primary ignition circuit that bypasses the resistance unit in the primary circuit to provide full battery voltage to the ignition system during starting

______f. High voltage circuit which produces electrical current to jump spark plug gap

1. Primary ignition circuit
2. Electronic ignition system
3. Dwell
4. Timing
5. Ignition bypass circuit
6. Secondary ignition circuit

2. State the purpose of the ignition system.

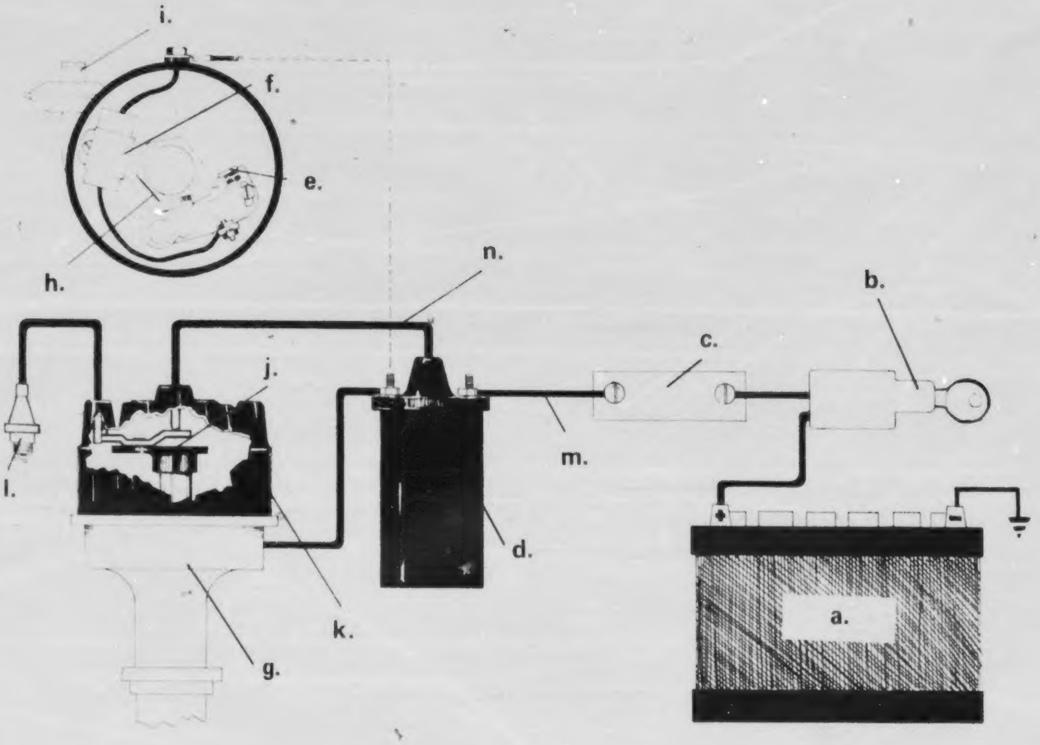
____

____

____

____

3. Identify the following components of the ignition system by writing the correct names in the blanks provided.


i.
f.
e.
h.
n.
b.
c.
j.
l.
m.
d.
k.
g.
a.

a. ______________________

b. ______________________

c. ______________________

d. ______________________

e. ______________________

f. ______________________

g. ______________________

h. ______________________

i. ______________________

j. ______________________

k. ______________________

l. ______________________

m. ______________________

n. ______________________

4. Match the ignition system components on the right to the correct functions.

______a. Contains the contact points and condenser; distributes the high voltage current from the coil to the proper cylinder

______b. Carries high voltage from the secondary windings of the coil to the spark plug (heavily insulated wire)

______c. Regulates the timing of the high voltage circuit for best ignition during all speed and load conditions

______d. Provides a spark gap inside the engine cylinder to ignite the fuel-air mixture

______e. Opens and closes the contact points

______f. Takes the high voltage current from the coil and directs it to the correct cylinder

______g. Serves as a source of electrical power

______h. Holds the coil and spark plug wires in a sequence and provides a cover for the distributor

______i. Carries low voltage from the battery to the primary windings of the ignition coil (light wire)

______j. Stores extra current as the contact points open to prevent arcing and burning; aids coil primary winding to build up magnetic field by releasing its charge back into the circuit as the points close

______k. Opens and closes the primary circuit from battery to coil

______l. Makes and breaks the primary circuit to allow the coil to produce high voltage at the spark plugs

______m. Reduces voltage in the primary circuit to protect the contact points

______n. Transforms low voltage into high voltage necessary to jump the spark plug gap

1. Battery
2. Condenser
3. Distributor
4. Spark plug
5. Spark-advance mechanism
6. Ignition coil
7. Primary ignition wire
8. Breaker cam
9. Ignition switch
10. Rotor
11. Resistance unit
12. Secondary ignition cable
13. Contact point or breaker point
14. Distributor cap

5. Identify the following components of the distributor.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

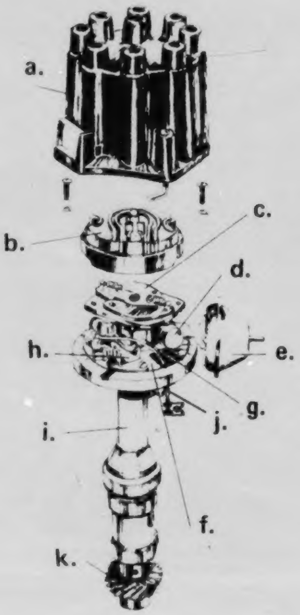
g. ______________________________

h. ______________________________

i. ______________________________

j. ______________________________

k. ______________________________



6. Distinguish between the components of the primary and secondary ignition circuits by placing a "P" in front of the components in the primary ignition circuit and an "S" in front of those in the secondary ignition circuit.

______a. Resistance unit

______b. Condenser

______c. Distributor cap

______d. Ignition switch

______e. Rotor

______f. Secondary winding of the coil

______g. High voltage cable

______h. Low voltage wire

______i. Contact points

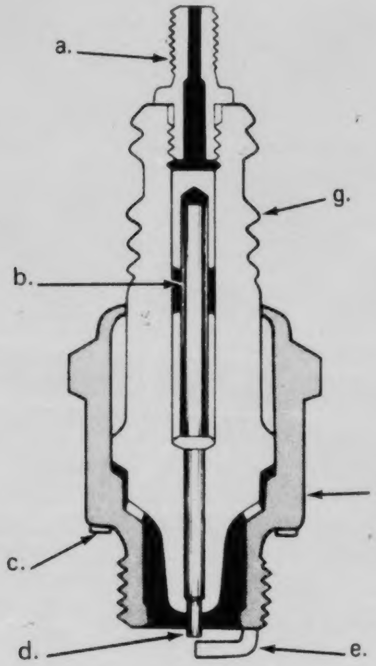
______j. Battery

______k. Primary winding of the coil

______l. Spark plug

7. Discuss the operation of the ignition system through one complete cycle, beginning with the battery.

8. Identify the parts of the spark plug in the diagram below by writing the correct names in the blanks.



a. ______________________

b. ______________________

c. ______________________

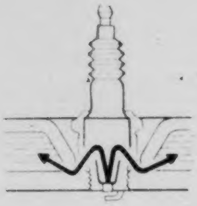
d. ______________________

e. ______________________

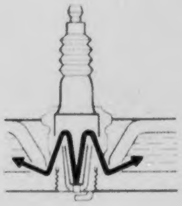
f. ______________________

g. ______________________

9. Label the following spark plugs according to heat range.



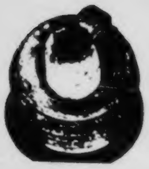
a. ______________________



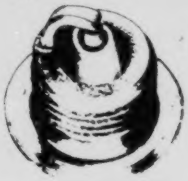
b. ______________________

10. Identify the spark plug conditions in the illustrations by writing the correct cause in the blanks provided.

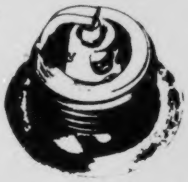
1. Normal
2. Carbon deposits
3. Oil deposits
4. Too hot
5. Preignition
6. High-speed glazing
7. Modifier deposits
8. Splashed deposits



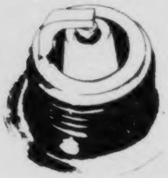
a. ____________



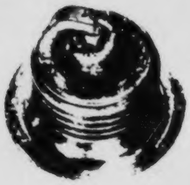
b. ____________



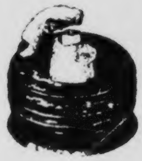
c. ____________



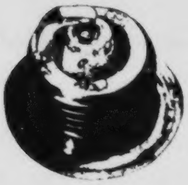
d. ____________



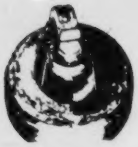
e. ____________



f. ____________



g. ____________



h. ____________

11. Name the two types of secondary ignition cables.

    a. ______________________________

    b. ______________________________

12. Distinguish between the transistorized and capacitive discharge ignition systems by placing a "T" in front of the descriptions of a transistorized type and a "C" in front of the capacitive type.

    ______a. System contains special ignition distributor, amplifier, and special coil

    ______b. Amplifier is included in circuit between points and ignition coil

    ______c. Transistors allow very low voltage through the points and battery voltage to the primary windings in coil

    ______d. System operates to charge a capacitor to a high voltage which, on signal from distributor, is then discharged through the primary windings in coil

13. Discuss the relationship of the electronic ignition system to the conventional ignition system.

    ____

    ____

    ____

    ____

    ____

14. List four advantages of the electronic ignition system.

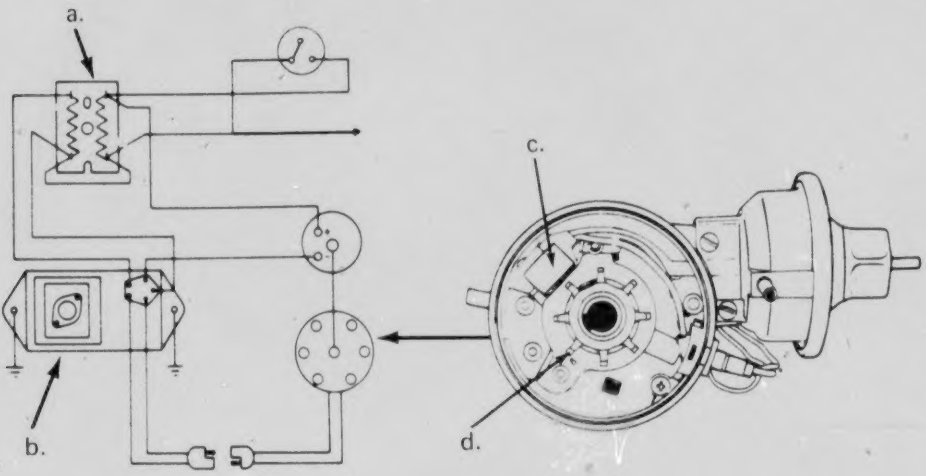
    a. ______________________________

    b. ______________________________

    c. ______________________________

    d. ______________________________

15. Identify the major components of the electronic ignition system in the diagram below.



a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

16. Match the major components of the electronic ignition system on the right to the correct functions.

_____a. Sends a small voltage pulse to the control unit to trigger switching transistor to stop current flow in the coil primary windings

_____b. Controls the flow of current in the primary windings of the ignition coil and maintains dwell

_____c. Maintains constant primary current with variations in engine speed

_____d. Rotates with the distributor shaft, producing a voltage pulse in the magnetic pickup

1. Resistance unit
2. Magnetic pickup assembly
3. Armature or reluctor
4. Control unit

17. Arrange in the proper order the operation of the electronic ignition system.

_____a. As the armature tooth approaches the magnetic pickup, voltage begins to build up in the magnetic pickup circuit

_____b. With the primary circuit open, the magnetic field in the coil collapses and induces a high voltage surge in the secondary circuit

_____c. As the armature tooth aligns with the magnetic pickup, the voltage in the magnetic pickup circuit is sufficient to signal the switching transistor to shut off current flow in the primary circuit

_____d. With the ignition switch On and the armature tooth not aligned with the magnetic pickup, the primary circuit has current flowing from the ignition switch to the resistance unit (if used) through the primary windings of the coil through the control unit to ground

18. Demonstrate the ability to:

a. Check and set ignition timing.

b. Remove and replace a distributor.

c. Remove and replace contact points and condenser.

d. Adjust dwell on an externally adjustable distributor.

e. Test and adjust distributor on distributor tester.

f. Remove, inspect, service, and replace spark plugs.

(NOTE: If these activities have not been accomplished prior to the test, ask the instructor when they should be completed.)

IGNITION SYSTEM
UNIT IV

ANSWERS TO TEST

1. a. 3
   b. 4
   c. 1
   d. 2
   e. 5
   f. 6

2. To provide a high voltage spark to ignite the fuel-air mixture in the combustion chamber

3. a. Battery
   b. Ignition switch
   c. Primary resistance unit
   d. Ignition coil
   e. Contact points
   f. Condenser
   g. Distributor
   h. Breaker cam
   i. Spark-advance mechanism
   j. Rotor
   k. Distributor cap
   l. Spark plug
   m. Primary ignition wire
   n. Secondary ignition cable

4. a. 3
   b. 12
   c. 5
   d. 4
   e. 8
   f. 10
   g. 1
   h. 14
   i. 7
   j. 2
   k. 9
   l. 13
   m. 11
   n. 6

5. a. Distributor cap
   b. Rotor
   c. Centrifugal advance mechanism
   d. Condenser
   e. Vacuum advance unit
   f. Breaker plate
   g. Distributor cam
   h. Contact points
   i. Distributor housing
   j. Primary lead wire
   k. Distributor drive gear

6. a. P
   b. P
   c. S
   d. P
   e. S
   f. S
   g. S
   h. P
   i. P
   j. P
   k. P
   l. S

7. Discussion should include:

   a. With the ignition switch on and the contact points closed, low voltage current flows from the battery through the primary winding of the coil and through the contact points to ground

   b. The flow of low voltage current through the primary windings of the coil causes a magnetic field buildup

   c. As the contact points open, current continues to flow across the point surfaces; the condenser attached to the points absorbs this flow of current

   d. Stopping this flow of current causes the magnetic field of the coil primary windings to collapse across the secondary coil windings, causing a high voltage surge

   e. This high voltage surge is directed from the secondary windings of the coil through the distributor cap and rotor and on to the spark plug to ground

8. a. Ignition cable terminal
   b. Center electrode resistance unit
   c. Gas seal
   d. Center electrode tip
   e. Ground electrode
   f. Steel shell
   g. Porcelain insulator

9. a. Cold
   b. Hot

10. a. 5
    b. 2
    c. 8
    d. 1
    e. 3
    f. 7
    g. 4
    h. 6

11. a. Radio suppression
    b. Stranded wire

12. a. C
    b. T
    c. T
    d. C

13. Discussion should include:

The electronic ignition system functions the same as the conventional ignition system; however, in the electronic system, an electronic control unit and its sensory device, a magnetic pickup, does the job of the ignition points of the conventional system

14. a. Requires much less maintenance during the life of the vehicle
    b. Has no moving parts in the primary circuit
    c. Maintains a constand dwell at all engine speeds and operating conditions
    d. Extends the efficient life of the spark plugs

15. a. Resistor unit
    b. Control unit
    c. Magnetic pickup assembly
    d. Armature

16. a. 2
    b. 4
    c. 1
    d. 3

17. a. 2
    b. 4
    c. 3
    d. 1

18. Performance skills evaluated to the satisfaction of the instructor

CHARGING SYSTEM
UNIT V

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify the components of the charging system. The student should be able to demonstrate the ability to remove, replace, disassemble, and reassemble a generator and alternator. This knowledge will be evidenced through demonstration and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Write the purpose of the charging system.
2. Match terms associated with the charging system to the correct definitions.
3. Match the charging system components to the correct purposes.
4. Identify the major parts of the generator.
5. Identify the major parts of the alternator.
6. Distinguish between an alternator and a generator.
7. List advantages of an alternator over a generator.
8. Explain why an alternator produces more current at low speed than a generator.
9. Discuss the construction of the stator.
10. Identify types of stator windings.
11. Describe the current and voltage regulation in the alternator.
12. Identify the types of voltage regulators for alternators.
13. Demonstrate the ability to:
    a. Remove and replace a generator.
    b. Disassemble, check, and reassemble a generator.
    c. Remove and replace an alternator.

d. Disassemble, check, and reassemble an alternator.

e. Test charging circuit resistance of an alternator.

f. Test current output of an alternator.

g. Test external type voltage regulator.

h. Test internal type voltage regulator on vehicle.

CHARGING SYSTEM
UNIT V

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss procedures outlined in the job sheets.

   G. Give test.

II. Unit references:

   A. Toboldt, William K., and Purvis, Jud. *Motor Services Automotive Encyclopedia.* Homewood, Illinois: Goodheart-Willcox Co., 1965.

   B. Stockel, Martin W. *Auto Service and Repair.* Homewood, Illinois: Goodheart-Willcox Co., 1969.

   C. *Chevrolet Passenger Car Shop Manual.* Detroit: Chevrolet Motor Div./General Motors Corp., 1957.

   D. Billiet, Walter E., and Goings, Leslie F. *Automotive Electrical Systems.* 3rd ed. Chicago: American Technical Society, 1970.

   E. *Chevrolet Chassis Overhaul Manual.* Chevrolet Motor Div./General Motors Corp., 1970.

   F. Crouse, William H. *Automotive Electrical Equipment.* 8th ed. New York: McGraw-Hill Book Co., 1976.

CHARGING SYSTEM
UNIT V

INFORMATION SHEET

I. Purpose of the charging system--To recharge the battery and maintain a supply of electrical current to meet the operating needs of the automobile

II. Terms and definitions

   A. Ampere--Unit of measure used in expressing the rate of current flow in a circuit

   B. Volt--Unit of electrical pressure or force that will move a current of one ampere through a resistance of one ohm

   C. Ohm--Unit of measure used to indicate the amount of resistance to the flow of electricity in a given circuit

   D. Diode--Device that will allow current to flow in one direction and will block current in the opposite direction

   E. Short circuit--Wire touching another wire and providing a shorter path for current to flow

   F. Open circuit--Circuit in which a wire is broken or disconnected

   G. Grounded circuit--Circuit in which a wire touches ground, causing the current to flow to ground instead of through the circuit

   H. Rectifier--Group of diodes that convert alternating current to direct current

   I. Phase--Stator winding with a positive and negative diode

   (NOTE: Automotive alternators are of the three-phase type containing three windings and six diodes.)

   J. Rated output--Maximum D.C. amperage an alternator can produce

III. Charging system components (Transparency 1)

   A. Battery--Supplies electrical power for starting and for operating the electrical system during slow generator speeds or heavy electrical load

   B. Ammeter--Measures the rate of current flow

   C. Regulator--Controls generator voltage and current output

INFORMATION SHEET

D. Generator or alternator--Supplies electricity to the battery and the electrical system when driven mechanically by the engine

E. Indicator light--Indicates a *no charge* condition in the charging system

IV. Parts of a generator (Transparency 2)

A. Pulley

B. Fan

C. Drive end frame

D. Generator housing

E. Field coils

F. Commutator

G. Through bolt

H. Brushes

I. Armature

V. Parts of the alternator (Transparency 3)

A. Slip ring end frame

B. Rotor assembly

C. Stator assembly

D. Drive end frame

E. Diodes

F. Brush assembly

G. Pulley

VI. Differences between an alternator and a generator (Transparency 4)

A. Alternator

1. Rotates the field inside the stationary windings

2. Rectifies the A.C. current to D.C. with a series of diodes

INFORMATION SHEET

B. Generator

1. Rotates the armature windings inside the field

2. Rectifies the current through the use of a segmented commutator and brushes

VII. Advantages of an alternator over a generator

A. Produces higher output at low engine speeds

B. Requires less maintenance because of its simple construction

VIII. Reason alternator produces more current at low speed than generator--An alternator has more pole pieces than a generator so that many more magnetic lines of force are cut during one revolution of the rotor

(NOTE: The alternator usually has fourteen pole pieces and the generator usually has two.)

IX. Stator construction (Transparency 5)

A. The core is constructed of a predetermined number of stamped steel plates riveted together to form a laminated core

B. Stator has three different coil windings equally spaced around the core

C. Stator is electrically connected to the rectifier assembly containing one positive and one negative diode rectifier for each winding

X. Types of stator windings (Transparency 5)

A. Wye connected

(NOTE: The three coils are connected together at one end to form a common point. The common point is called the *stator neutral junction*.)

B. Delta connected

(NOTE: The three coil windings are joined at their ends to form an electrical closed circuit with each terminal end connected to a positive and negative diode.)

XI. Current and voltage regulation in alternator

A. Current capacity is regulated by the number of turns of wire in each phase

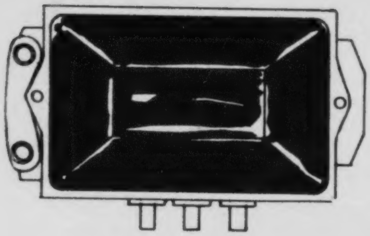
B. Voltage is regulated by controlling the current flow in the rotor field

INFORMATION SHEET

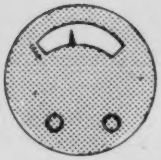
XII. Types of voltage regulators for alternators (Transparency 6)

- A. Electromechanical
- B. Transistorized
- C. Electronic or solid state
  - 1. Internal
  - 2. External

Charging System Components

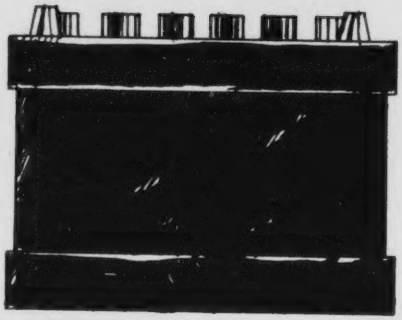


Regulator

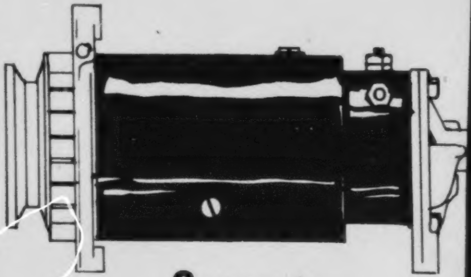


Ammeter

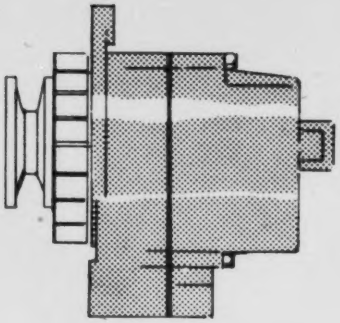
(NOTE: Indicator light replaces ammeter on some models.)



Battery



Generator

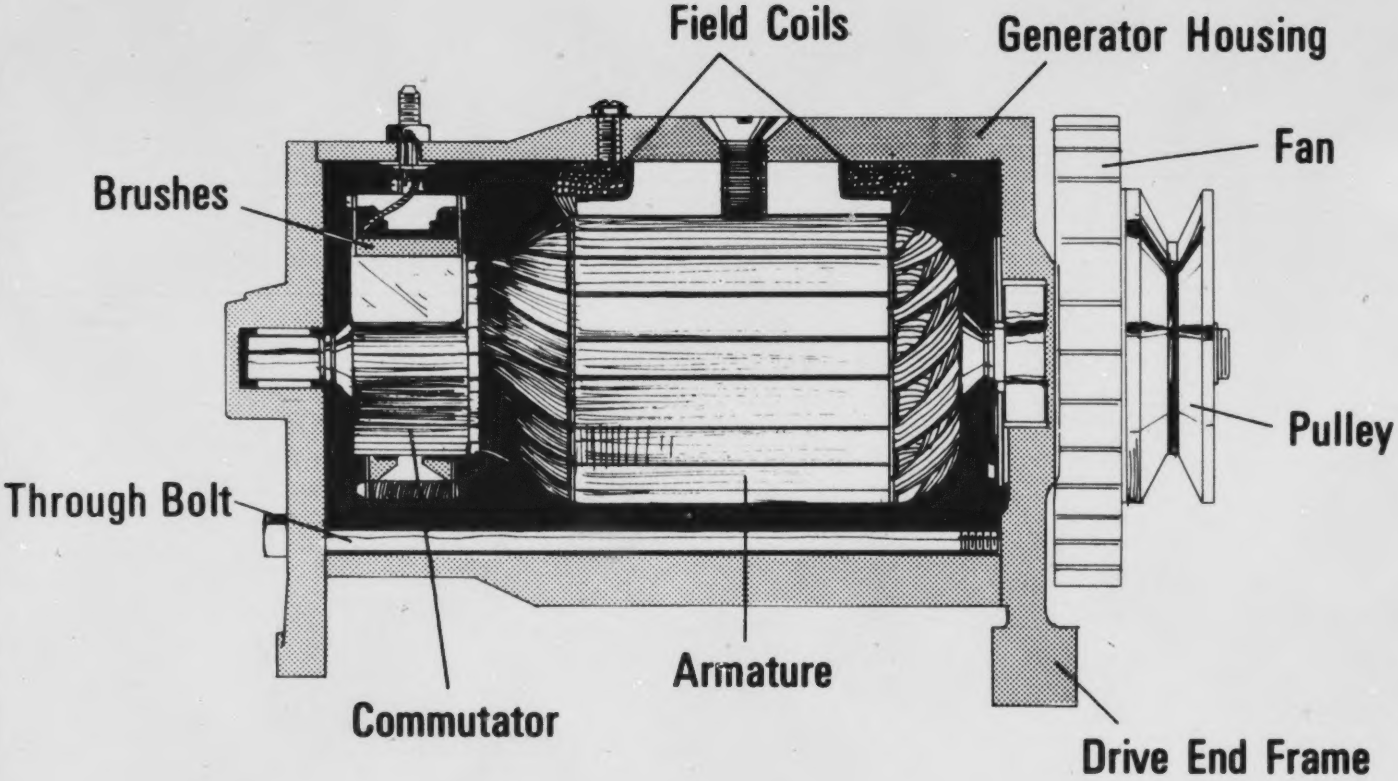


Alternator

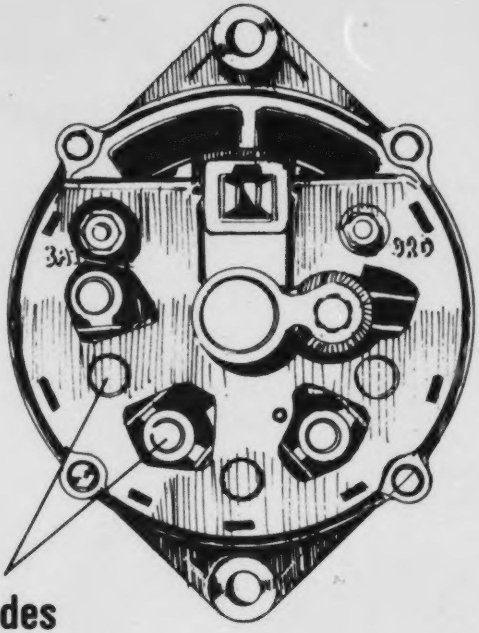
532

[redacted]

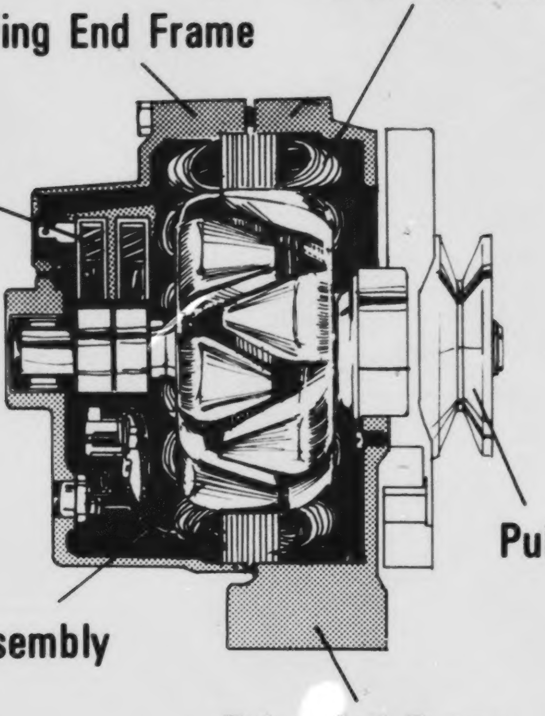
Parts of the Generator


Field Coils
Generator Housing
Fan
Brushes
Pulley
Through Bolt
Armature
Commutator
Drive End Frame

Parts of the Alternator



Diodes



Stator Assembly

Slip Ring End Frame

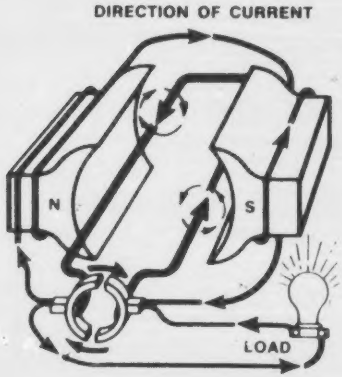
Brush Assembly

Pulley

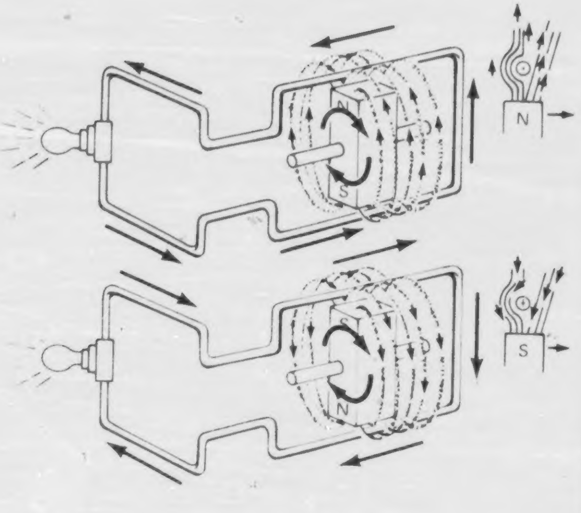
Rotor Assembly

Drive End Frame

Differences in Alternator and Generator

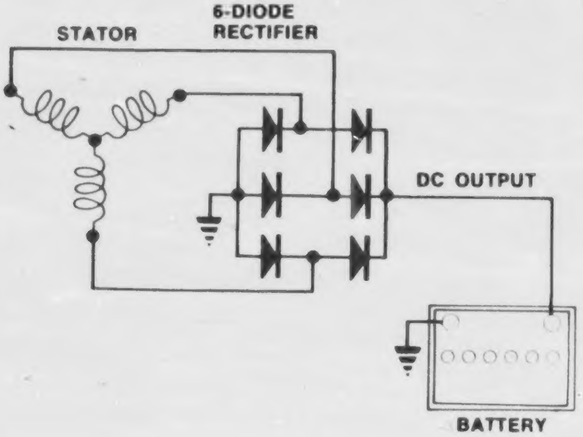

DIRECTION OF CURRENT
N
S
LOAD

Generator

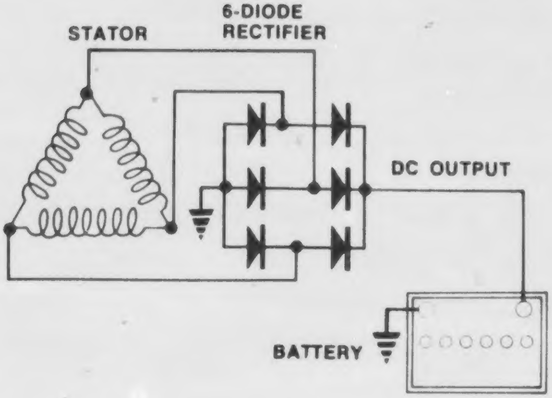


Alternator

Stator Construction

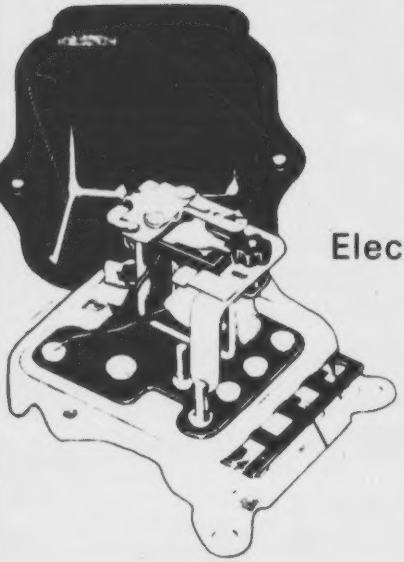

STATOR
6-DIODE RECTIFIER
DC OUTPUT
BATTERY

Wye-Connected Stator Windings

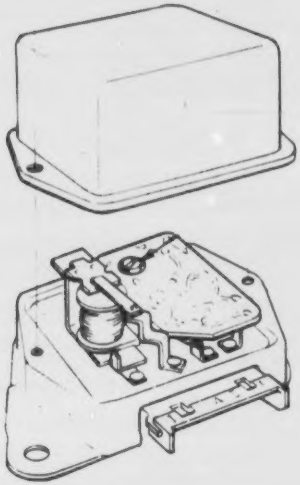

STATOR
6-DIODE RECTIFIER
DC OUTPUT
BATTERY

Delta-Connected Stator Windings

Types of Voltage Regulators

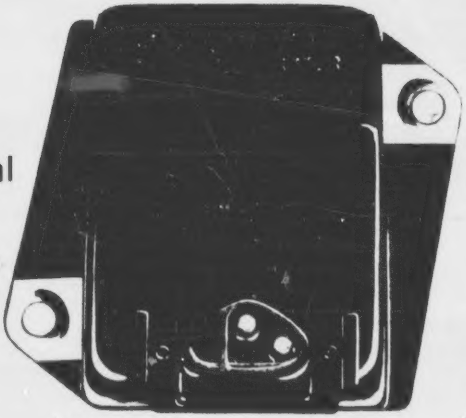


Electromechanical

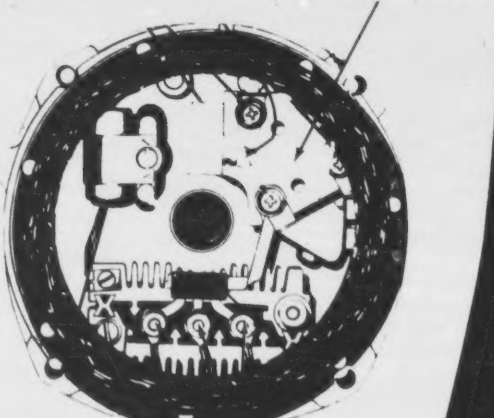


Transistorized

Electronic or Solid State



Electronic External



Electronic Internal

CHARGING SYSTEM
UNIT V

JOB SHEET #1--REMOVE AND REPLACE A GENERATOR

I. Tools and equipment

   A. Basic hand tool set

   B. Suitable pry bar

   C. Belt tension gauge

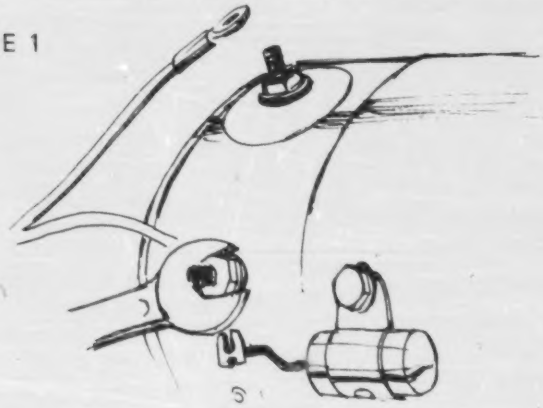
   D. Fender cover

   E. Safety glasses

II. Procedure

   A. Remove the leads from the generator terminals (Figure 1)

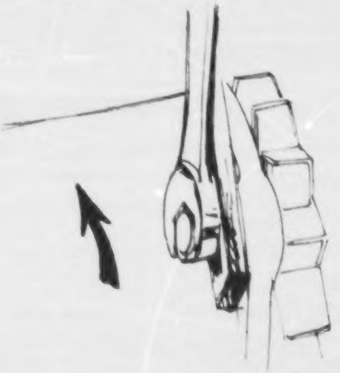
FIGURE 1



   B. Remove the generator belt adjusting bolt

   C. Move the generator toward the engine (Figure 2)

FIGURE 2

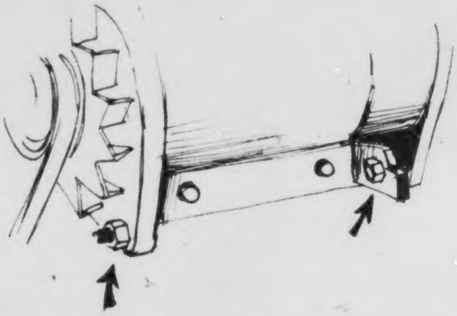


JOB SHEET #1

D. Remove the generator belt from the generator pulley

E. Remove the bolts holding the generator to the engine mounting bracket (Figure 3)

FIGURE 3



F. Lift the generator out of the bracket

G. Service the generator as required

H. Position the generator in the engine mounting bracket

I. Start generator retaining bolts and tighten lightly

J. Position generator belt on pulley and move generator away from engine to tighten belt

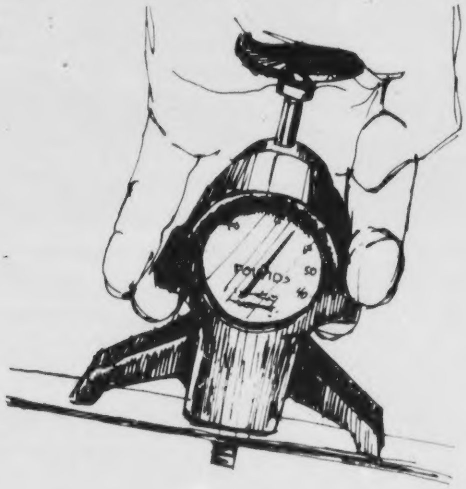
K. Install generator adjusting bolt

L. Pry the generator away from engine to adjust generator belt and tighten adjusting bolt and mounting bolts securely

M. Check generator belt tension with a belt tension gauge and readjust if not within manufacturer's specifications (Figure 4)

(NOTE: The generator belt must be adjusted properly.)

FIGURE 4



JOB SHEET #1

N. Install wire leads that were removed from generator

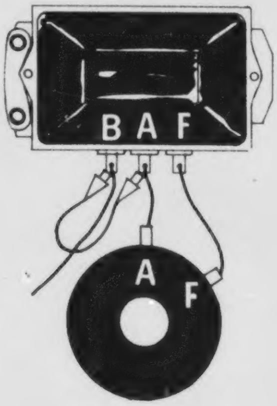
(NOTE: On cars using the condenser on generator, the condenser lead is attached to the "A" terminal, never to the "F" terminal.)

O. Polarize the generator before starting the engine

1. Polarize "A" circuit generators by holding one end of a jumper wire against the regulator BAT terminal and momentarily touching the other end of the jumper wire on the regulator ARM or GEN terminals (Figure 5)

"A" CIRCUIT

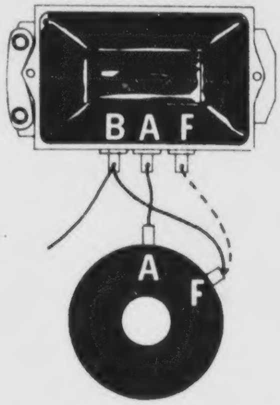
FIGURE 5



2. Polarize "B" circuit generators by removing the lead from the FIELD terminal of the regulator and momentarily touching the "F" lead to the BAT terminal of the regulator (Figure 6)

"B" CIRCUIT

FIGURE 6



CHARGING SYSTEM
UNIT V

JOB SHEET #2--DISASSEMBLE, CHECK, AND REASSEMBLE A GENERATOR

I. Tools and equipment

   A. Basic hand tool set

   B. Shop towels

   C. Suitable armature and field testing equipment

   D. Generator pulley puller

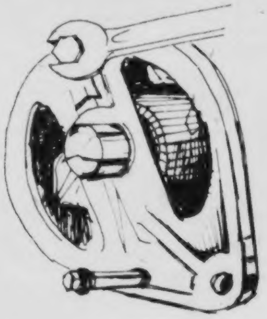
   E. Safety glasses

II. Procedure

   A. Disassemble generator

      1. Remove generator through bolts (Figure 1)

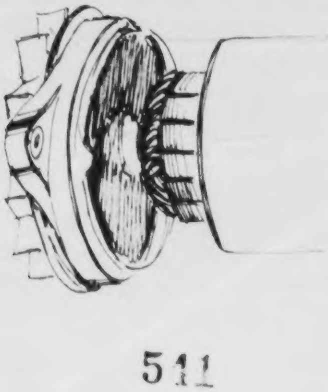
FIGURE 1



      2. Tap the generator commutator end frame lightly and remove from housing

      3. Remove the drive end frame and armature assembly from the generator housing (Figure 2)

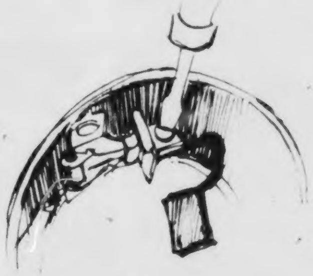
FIGURE 2



JOB SHEET #2

4. Remove the generator brushes (Figure 3)

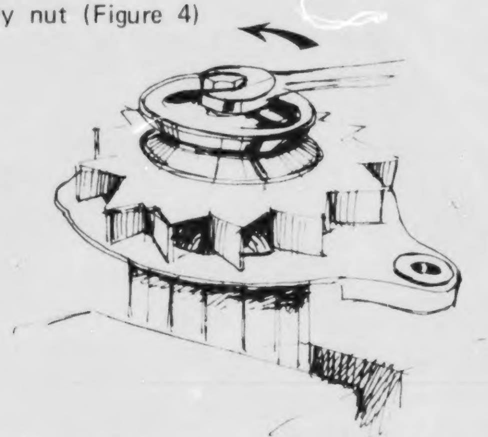
FIGURE 3



5. Place the armature and drive end frame assembly in a vise (Figure 4)

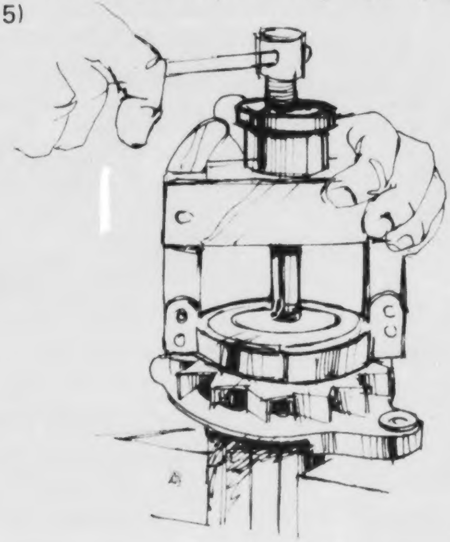
6. Remove the pulley nut (Figure 4)

FIGURE 4



7. Remove the pulley from the armature using a pulley puller as required (Figure 5)

FIGURE 5



JOB SHEET #2

8. Slide the drive end frame and spacer columns off armature shaft

9. Remove armature from vise

10. Remove bearing retainer and gasket from drive end frame

11. Remove drive end bearing from drive end frame

B. Clean and inspect generator

1. Clean all generator components

   (NOTE: Do not wash the fields or armature with a degreasing solvent.)

2. Inspect generator drive end frame bearings for roughness or scored races

3. Inspect generator brush holders to see if they are bent or deformed; check generator brush springs for proper spring tension

4. Check fit of armature shaft in bushing in commutator end frame

   (NOTE: If bushing is excessively worn, the end frame should be replaced.)

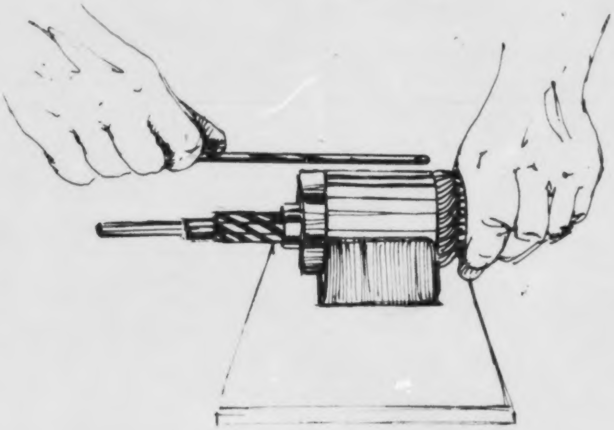
5. Inspect armature commutator for roughness or out-of-round condition

   (NOTE: If armature commutator is rough or out-of-round, it should be turned or serviced on an armature turning lathe.)

6. Test armature for shorts (Figure 6)

   (NOTE: Place the armature on a growler and rotate the armature while holding a hacksaw blade over the armature core. If the blade vibrates, the armature is shorted and will require replacement.)

FIGURE 6

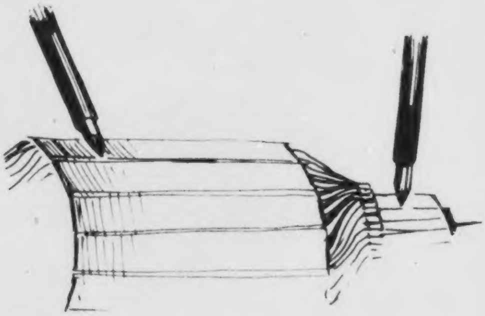


JOB SHEET #2

7. Test armature for ground (Figure 7)

   (NOTE: Place one lead of a test lamp on the armature core or shaft and the other on the commutator. If the lamp lights, the armature is grounded and will require replacement.)

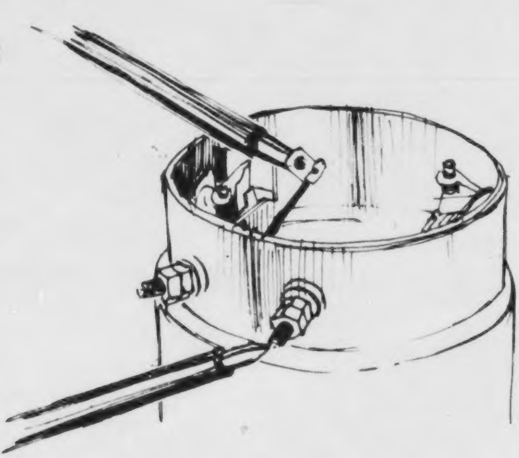
FIGURE 7



8. Test field coil for open circuit (Figure 8)

   (NOTE: Place one lead of a test lamp on field terminal and the other lead on the end of the field coil lead through the armature terminal. If lamp does not light, the fields are open and must be replaced.)

FIGURE 8

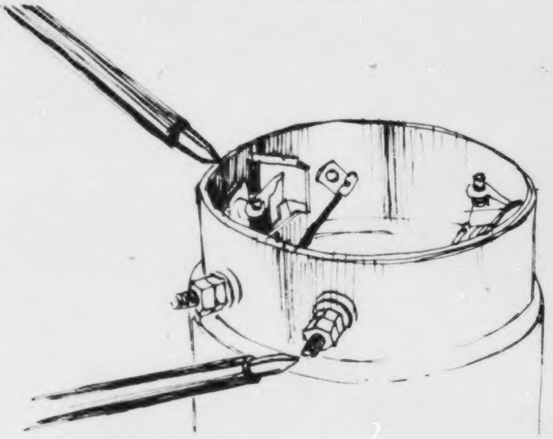


JOB SHEET #2

9. Test field coil for ground on "A" circuit only (Figure 9)

   (NOTE: Place one lead of a test lamp on generator housing ground and the other lead on field terminal. If lamp lights, the field coils are grounded and must be repaired or replaced.)

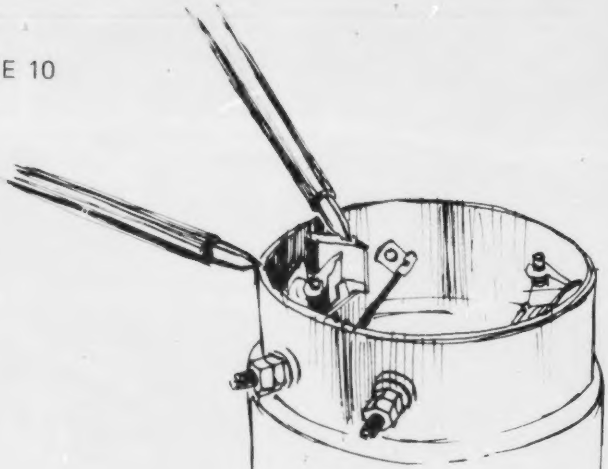
FIGURE 9



10. Check insulated brush holder for ground (Figure 10)

    (NOTE: Place one lead of a test lamp on brush holder and the other lead on the generator housing. If lamp lights, insulated brush is grounded and must be repaired.)

FIGURE 10



(NOTE: After all parts have been inspected and all worn or damaged parts have been repaired or replaced, the generator is ready for reassembly.)

JOB SHEET # 2

C. Reassemble generator (Figure 11)

1. Pack the generator ball bearings with high melting point bearing grease

2. Install the ball bearing in the drive end frame

   (NOTE: Make sure gasket is in place and retainer screws are tightened securely.)

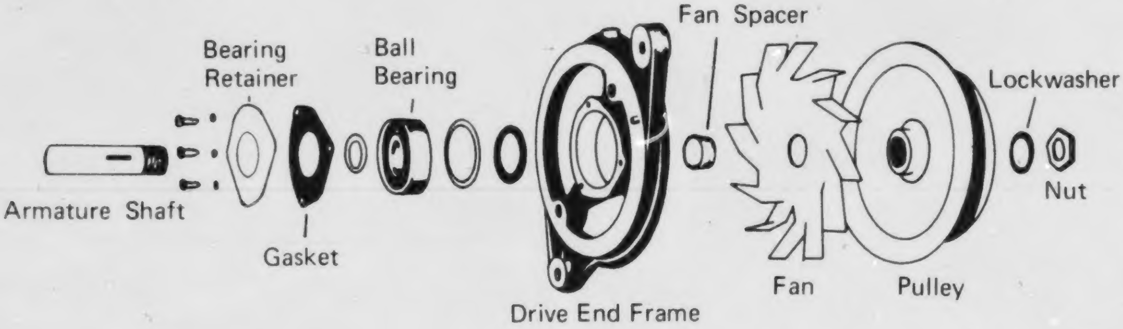
3. Install the drive end frame and bearing assembly onto the armature shaft

   (NOTE: If ball bearing spacer is used, make sure it is in place.)

4. Install fan spacer, fan, pulley, and retaining nut

5. Tighten retaining nut securely

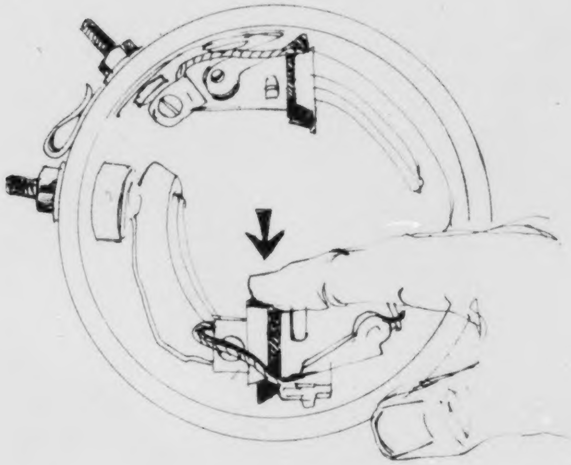
FIGURE 11


Fan Spacer
Bearing Retainer
Ball Bearing
Lockwasher
Nut
Armature Shaft
Gasket
Fan
Pulley
Drive End Frame

JOB SHEET #2

6. Install new brushes in brush holders and push brushes back against spring tension (Figure 12)

FIGURE 12



7. Install armature and drive end frame assembly into generator housing

8. Release brushes so they will contact commutator

9. Assemble commutator end frame over end of armature shaft

10. Rotate both end frames until dowels engage; start through bolts

11. Tighten through bolts securely

12. Check generator operation before replacing on vehicle

CHARGING SYSTEM
UNIT V

JOB SHEET #3--REMOVE AND REPLACE AN ALTERNATOR

I. Tools and equipment

  A. Basic hand tool set

  B. Belt tension gauge

  C. Fender cover

  D. Battery cable clamp removal tool

  E. Pliers

  F. Safety glasses

II. Procedure

  A. Remove battery ground cable

  B. Remove wire leads from alternator

  (NOTE: The battery lead on the alternator will be dangerous to remove unless the battery ground cable has been removed from the battery.)

  C. Remove the alternator belt adjusting bolt

  D. Move the alternator toward the engine

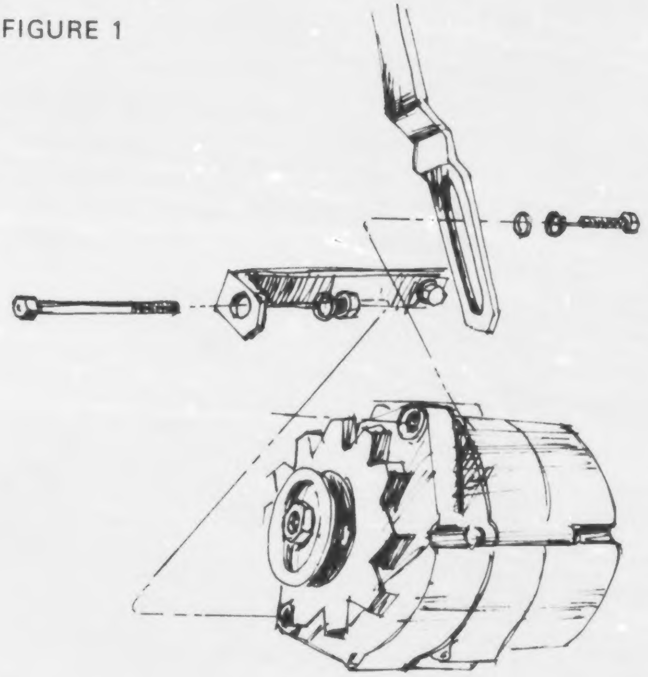
  E. Remove the alternator belt from the alternator pulley

  F. Remove the bolts holding the alternator to the engine mounting bracket

  (NOTE: Refer to Figure 1 on the following page.)

JOB SHEET #3

FIGURE 1



G. Lift the alternator out of the bracket

H. Service alternator as required

I. Position the alternator in the engine mounting bracket

J. Start alternator retaining bolts and tighten securely

K. Position alternator belt on pulley and move alternator away from engine to tighten belt

L. Pry the alternator away from the engine to adjust the alternator belt tension

(NOTE: Use caution when adjusting the alternator belt to avoid damaging the alternator. Refer to manufacturer's recommendations for tightening procedures.)

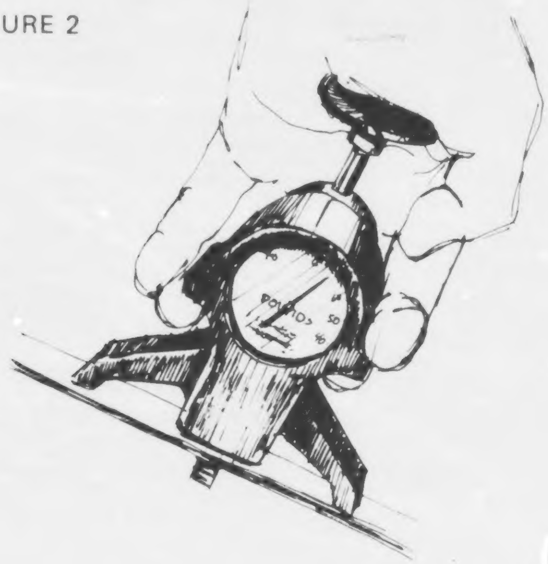
M. Install the alternator adjusting bolt

JOB SHEET #3

N. Check alternator belt tension with a belt tension gauge and adjust to manufacturer's specifications (Figure 2)

(NOTE: The alternator belt must be adjusted properly.)

FIGURE 2



O. Install wire leads that were removed from the alternator and tighten securely

P. Install battery ground cable

(CAUTION: Never attempt to polarize an alternator.)

CHARGING SYSTEM
UNIT V

JOB SHEET #4--DISASSEMBLE, CHECK, AND REASSEMBLE AN ALTERNATOR

I. Tools and equipment

   A. Basic hand tool set

   B. Alternator pulley removal tools

   C. Alternator diode removal equipment

   D. Alternator testing equipment

   E. Torque wrench

   F. Safety glasses

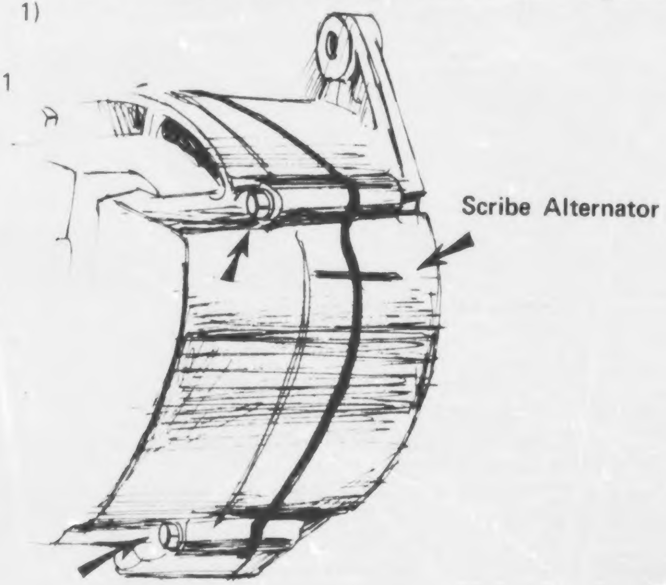
II. Procedure

   A. Disassemble alternator

      1. Scribe the alternator before disassembly (Figure 1)

      2. Remove through bolts holding the end frames together (Figure 1)

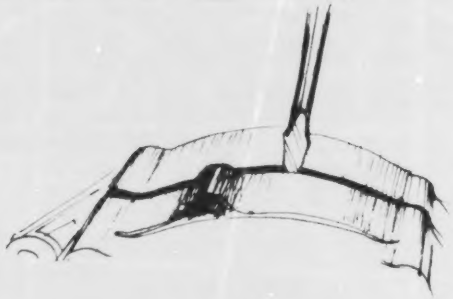
FIGURE 1



JOB SHEET #4

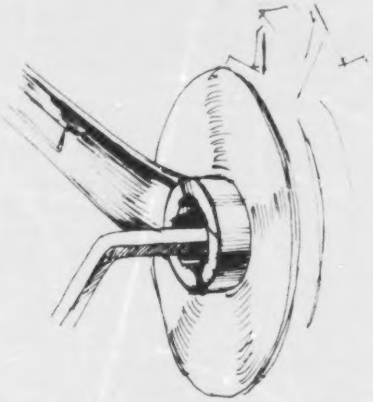
3. Pry at bolt locations to separate the drive end frame from the slip ring end frame (Figure 2)

FIGURE 2



4. Remove the slip ring end frame and stator (as an assembly) from drive end frame and rotor assembly
5. Remove the three stator lead attaching nuts
6. Separate stator from slip ring end frame
7. Remove screws, brushes, and brush holder assembly
8. Remove heat sink from end frame
9. Remove pulley retaining nut (Figure 3)

FIGURE 3



10. Remove pulley and fan using pullers as required
11. Remove rotor and spacers from end frame assembly
12. Remove drive frame bearing retainer and bearing from drive end frame

B. Clean and inspect alternator

1. Wash all metal parts except stator and rotor assemblies

JOB SHEET #4

2. Clean bearings and inspect for pitting or roughness

   (NOTE: Replace bearings as required.)

3. Inspect rotor slip rings

   (NOTE: The slip rings should be clean and free of scratches; service as required.)

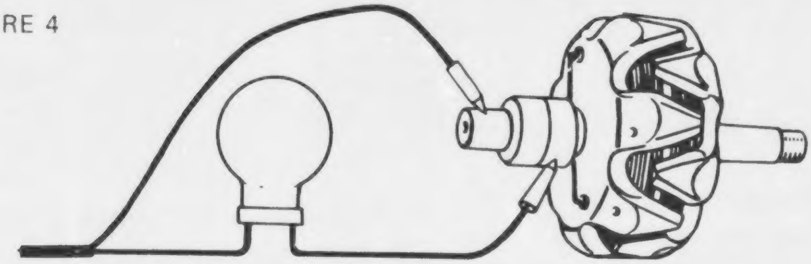
4. Inspect brushes for wear

   (NOTE: Replace brushes as required.)

5. Test the rotor for grounds (Figure 4)

   (NOTE: Connect one lead of a test lamp from either slip ring to the rotor shaft; if test lamp lights, the rotor is grounded.)

FIGURE 4

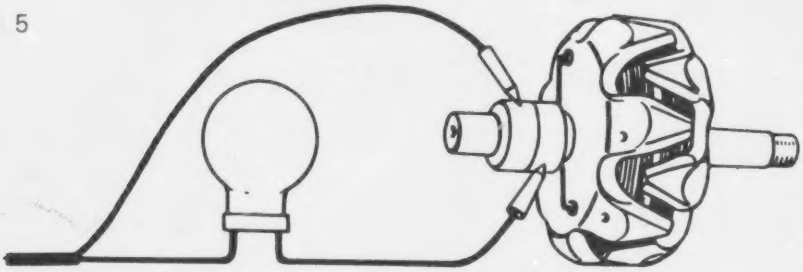


(Courtesy Standard Motor Products, Inc.)

6. Test the rotor for open circuit (Figure 5)

   (NOTE: Connect one lead of a test lamp to one slip ring and the other lead to the remaining slip ring; if the test lamp does not light, the circuit is open.)

FIGURE 5



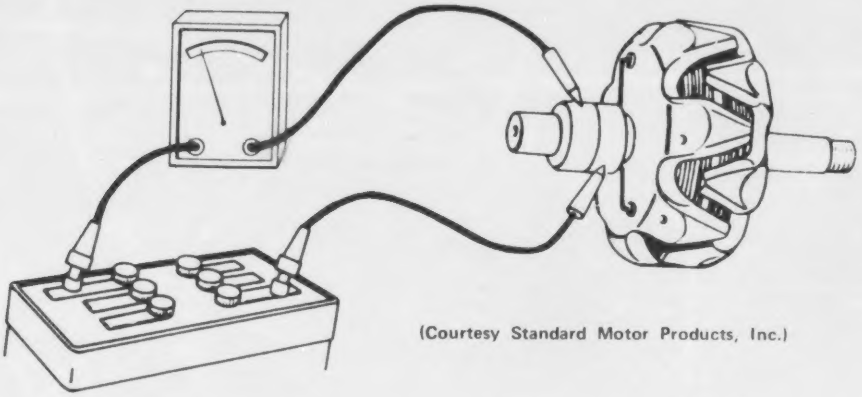
(Courtesy Standard Motor Products, Inc.)

JOB SHEET #4

7. Test the rotor for short circuit (Figure 6)

   (NOTE: Connect a twelve-volt battery and ammeter in series with the two slip rings. An ammeter reading above specified field amperage draw indicates a short circuit. Refer to manufacturer's specifications.)

FIGURE 6

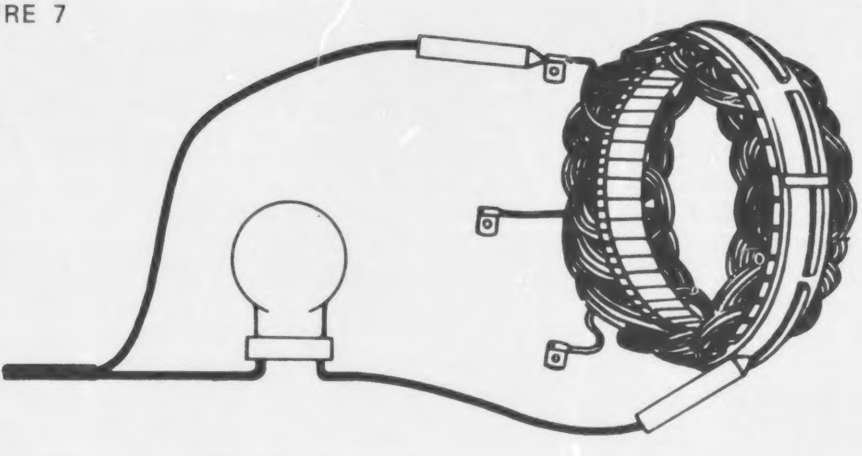


(Courtesy Standard Motor Products, Inc.)

8. Test the stator for grounds (Figure 7)

   (NOTE: Connect one lead of a test lamp to the stator frame. Connect the other lead to any stator lead. If the lamp lights, the windings are grounded.)

FIGURE 7



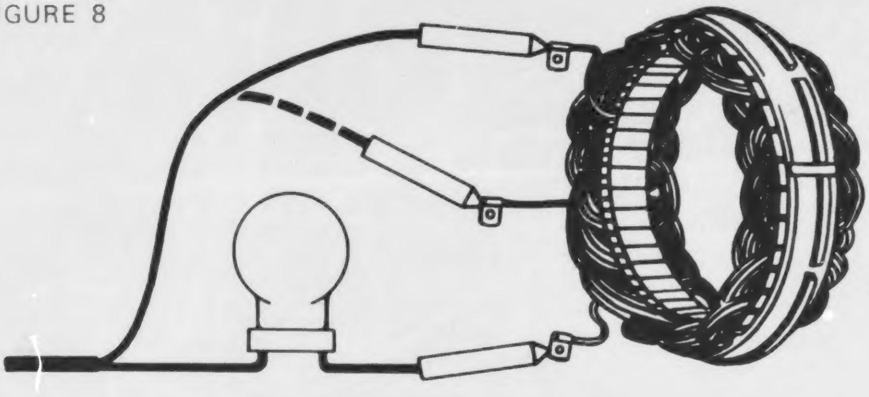
(Courtesy Standard Motor Products, Inc.)

JOB SHEET #4

9. Test the stator for open circuit (Figure 8)

(NOTE: Connect a test lamp between each pair of stator leads. If test lamp fails to light, the stator windings are open.)

FIGURE 8

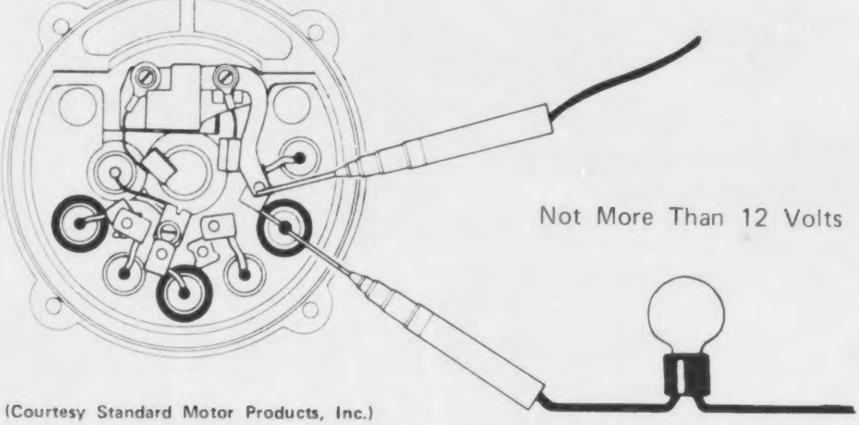


(Courtesy Standard Motor Products, Inc.)

10. Test the diodes (Figure 9)

(NOTE: A test lamp of not more than twelve volts or an ohmmeter must be used to test diodes.)

FIGURE 9



(Courtesy Standard Motor Products, Inc.)

11. Test the heat sink diodes

(NOTE: Connect one lead of a twelve-volt test lamp to the heat sink and the other lead to the diode lead. If the lamp lights in both directions or fails to light at all, the diode is defective.)

JOB SHEET #4

12. Test the end frame diodes

    (NOTE: Connect one lead of a twelve-volt test lamp to the end frame and the other lamp lead to the diode lead. If lamp lights in both directions or fails to light at all, the diode is defective.)

13. Replace any parts found defective

14. Replace any diodes found defective

    (NOTE: Use proper diode removal and replacement tools.)

15. Replace slip ring end frame bearing assembly if grease supply is exhausted

    (NOTE: Make no attempt to relubricate and reuse bearings.)

16. Repack drive end bearings with proper lubricant

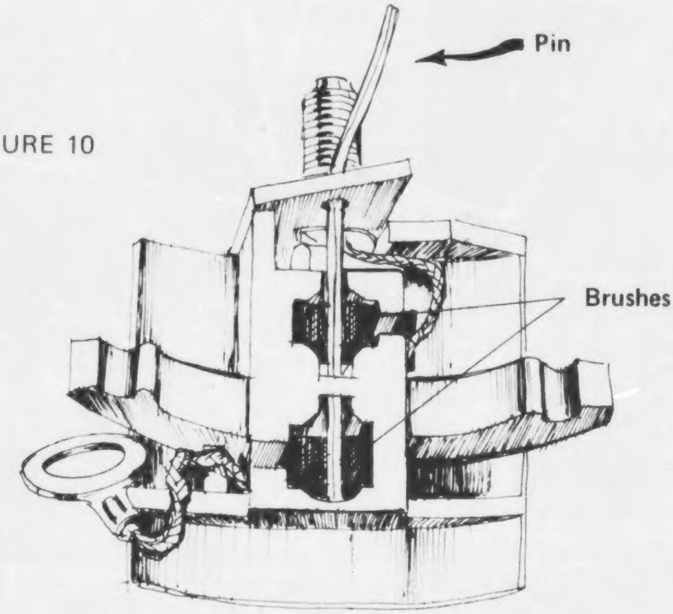
C. Reassemble alternator

1. Assemble heat sink to end frame

2. Install brush holder and brushes into slip ring end frame

   (NOTE: Insert a pin or wire through the hole to hold the brushes in the holder. See Figure 10.)

FIGURE 10



JOB SHEET #4

3. Install stator assembly in slip ring end frame and locate diode connectors over the relay, diode, and stator leads

4. Install and tighten terminal nuts securely

5. Install bearing in drive end frame

6. Install rotor in drive end frame

7. Install fan, spacer, pulley, and retaining nut

8. Tighten nut to manufacturer's specifications

9. Assemble slip ring end frame and stator assembly to drive end frame and rotor assembly

   (NOTE: Align end frames by referring to scribe marks put on during disassembly.)

10. Install through bolts in the end frame assembly

11. Tighten bolts securely

12. Remove wire holding brushes in place

CHARGING SYSTEM
UNIT V

JOB SHEET #5--TEST CHARGING CIRCUIT RESISTANCE OF AN ALTERNATOR

I. Tools and equipment

A. D.C. volt-ammeter

B. Carbon pile rheostat

C. Battery cable puller

D. Basic hand tool set

E. Safety glasses

F. Jumper wire

II. Procedure

(NOTE: The charging system circuit resistance test will show the amount of voltage drop between the alternator output terminal and the battery.)

A. Remove the battery ground cable

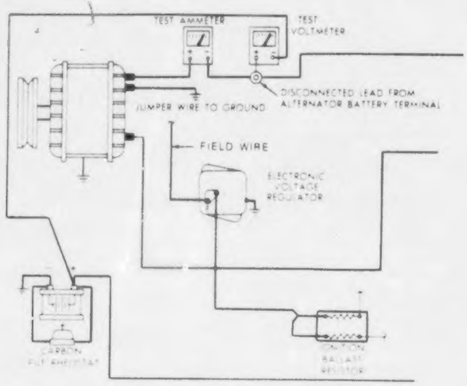
B. Disconnect the BAT lead at the alternator output terminal

C. Connect the ammeter in series between the alternator BAT terminal and the disconnected BAT lead wire (Figure 1)

D. Connect the positive lead of the voltmeter to the disconnected BAT lead wire (Figure 1)

E. Connect the negative lead of the voltmeter to battery positive post (Figure 1)

FIGURE 1


TEST AMMETER
TEST VOLTMETER
DISCONNECTED LEAD FROM ALTERNATOR BATTERY TERMINAL
JUMPER WIRE TO GROUND
FIELD WIRE
ELECTRONIC VOLTAGE REGULATOR
CARBON PILE RHEOSTAT
IGNITION BALLAST RESISTOR

JOB SHEET #5

F. Apply battery voltage to the alternator field (Figure 2)

1. Disconnect the field lead from the alternator and connect a jumper from field terminal to BAT terminal on internally grounded fields

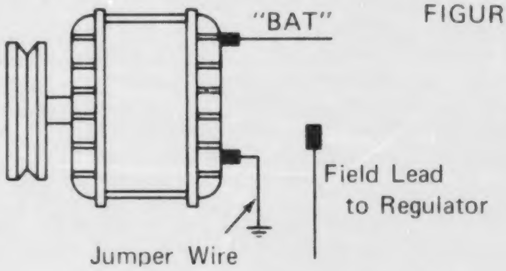
2. Disconnect the field "grounding" lead and connect a jumper from that terminal to ground on externally grounded fields

3. Ground the voltage regulator tab with a screwdriver through the D-shaped hole in the rectifier end frame of the alternator on internally mounted voltage regulator

(NOTE: Consult the appropriate service manual to determine the type system you have.)

FIGURE 2a

Internally Grounded Field


"BAT"
Field Lead
to Regulator
Jumper Wire

Externally Grounded Field

FIGURE 2b

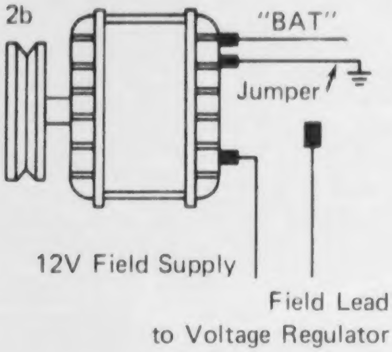
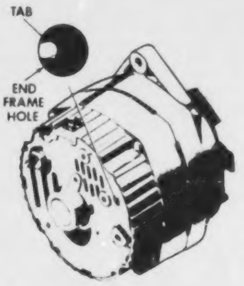

"BAT"
Jumper
12V Field Supply
Field Lead
to Voltage Regulator

FIGURE 2c

Internal Voltage Regulator


TAB
END
FRAME
HOLE

G. Reconnect the battery ground cable

H. Connect the variable carbon pile rheostat to the battery

(CAUTION: Be sure the carbon pile rheostat is in the Open or Off position before connecting the leads to the battery.)

I. Start and operate the engine at idle speed only

JOB SHEET #5

J. Adjust the engine speed and carbon pile rheostat to maintain 20 amperes flowing in the circuit

K. Observe the voltmeter reading

(NOTE: The voltmeter reading should not exceed 0.7 volts. If a higher voltage drop is indicated, inspect, clean, and tighten all connections in the charging circuit. A voltage drop test may be performed at each connection to locate the one with excessive resistance.)

L. Turn off carbon pile rheostat

M. Shut off the engine

N. Remove the ground battery cable

O. Remove the test equipment from the vehicle

P. Reconnect all alternator connections

Q. Reconnect the ground battery cable after making necessary repairs

CHARGING SYSTEM
UNIT V

JOB SHEET #6--TEST CURRENT OUTPUT OF AN ALTERNATOR

I. Tools and equipment

   A. D.C. volt-ammeter

   B. Basic hand tool set and safety glasses

   C. Carbon pile rheostat

   D. Jumper wire

   E. Engine tachometer

II. Procedure

(NOTE: The current output test determines whether or not the alternator is capable of delivering its rated current output.)

   A. Disconnect battery ground cable

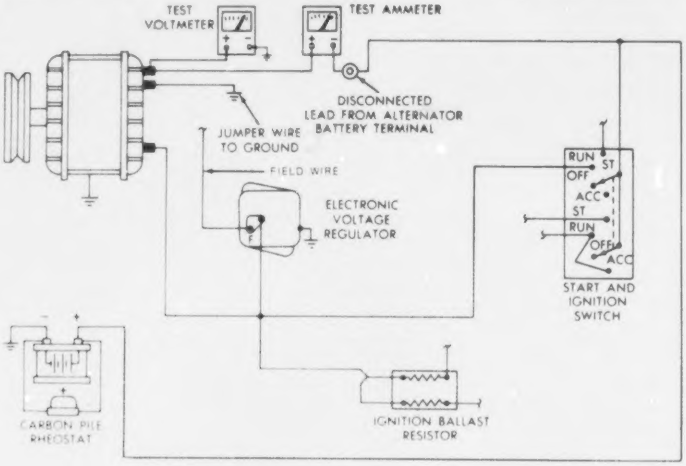
   B. Disconnect the BAT lead wire at the alternator output terminal

   C. Connect the ammeter in series between the alternator BAT terminal and the disconnected lead wire (Figure 1)

   D. Connect the positive lead of the voltmeter to the BAT terminal of the alternator (Figure 1)

   E. Connect the negative lead of the voltmeter to a good ground (Figure 1)

FIGURE 1


TEST VOLTMETER
TEST AMMETER
DISCONNECTED LEAD FROM ALTERNATOR BATTERY TERMINAL
JUMPER WIRE TO GROUND
FIELD WIRE
ELECTRONIC VOLTAGE REGULATOR
F
RUN
ST
OFF
ACC
ST
RUN
OFF
ACC
START AND IGNITION SWITCH
CARBON PILE RHEOSTAT
IGNITION BALLAST RESISTOR

JOB SHEET #6

F. Apply battery voltage to the alternator field

(NOTE: Consult the appropriate service manual to determine the type system you have.)

1. Disconnect the field lead from the alternator and connect a jumper wire from field terminal to BAT terminal on internally grounded fields (Figure 2a)
2. Disconnect the field grounding lead and connect a jumper wire from that field terminal to a good ground on externally grounded fields (Figure 2b)
3. Ground the voltage regulator tab with a screwdriver through the O-shaped hole in the rectifier end frame of the alternator on internally mounted regulators (Figure 2c)

FIGURE 2a
Internally Grounded Field

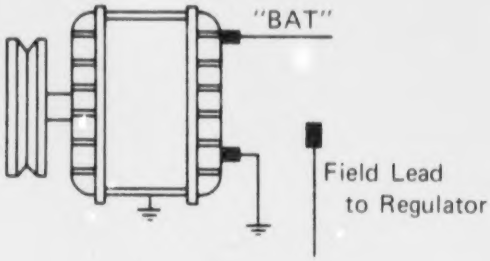
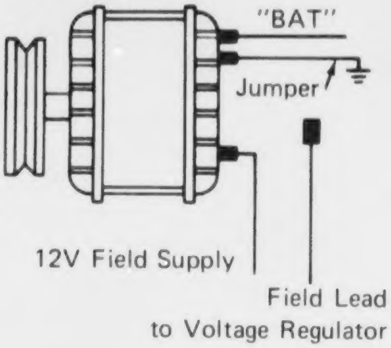
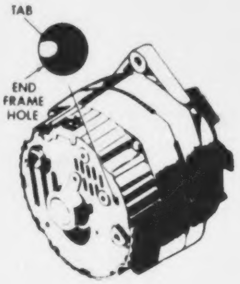


FIGURE 2b
Externally Grounded Field



Methods of Removing Regulators from Charging Circuit

FIGURE 2c
Internal Voltage Regulator



G. Connect the engine tachometer

H. Reconnect the battery ground cable

I. Connect the variable carbon pile rheostat between battery terminals

(NOTE: Refer to Figure 1.)

(CAUTION: Be sure the carbon pile rheostat is in the Open or Off position before connecting to the battery.)

JOB SHEET #6

J. Start and operate the engine at idle speed

K. Adjust carbon pile and engine speed in increments until a speed of 1,250 rpm and a voltmeter reading of 15 volts is obtained

(NOTE: These specifications may vary slightly from model to model so consult the appropriate service manual for accurate specifications.)

(CAUTION: Never allow voltmeter to read over 16 volts; damage to the charging system could occur.)

L. Read ammeter

(NOTE: Ammeter reading should be within the limits of rated output for the particular alternator being tested.)

M. Remove alternator for bench testing if readings are less than specified

(NOTE: Some models have a field load relay that should be tested for proper operation before removing the alternator.)

N. Reduce engine speed and turn off carbon pile rheostat after current output test is completed

O. Turn off ignition switch

P. Remove battery ground cable

Q. Remove test equipment and jumper wire

R. Reconnect field lead wire and ground battery cable

CHARGING SYSTEM
UNIT V

JOB SHEET #7--TEST EXTERNAL TYPE VOLTAGE REGULATOR

I. Tools and equipment

  A. D.C. volt-ammeter

  B. Basic hand tool set

  C. Safety glasses

II. Procedure

  A. Clean battery terminals

  B. Check specific gravity of battery electrolyte

  (NOTE: It should be above 1.200 to allow a proper regulator check.)

  C. Check alternator drive belt tension and adjust as necessary

  D. Connect voltmeter positive lead to battery positive post

  E. Connect voltmeter negative lead to a good ground

  F. Start and operate engine at approximately 1,250 rpm with lights and accessories turned off

  G. Check voltmeter reading

  (NOTE: The regulator is working properly if the voltage readings are in accordance with manufacturer's specifications.)

III. Test results

  A. Fluctuating or below limits voltage

    1. Check for good grounding of voltage regulator

    2. Test supply circuit to voltage regulator

    (NOTE: Supply circuit should equal battery voltage.)

    3. Test field circuit voltage

    (NOTE: Voltage through the field circuit, field wires, brushes, and rotor should be equal to battery voltage.)

    4. Replace the voltage regulator if tests A1, A2, and A3 are satisfactory

JOB SHEET #7

B. Voltage above the specified limits

1. Check supply circuit to voltage regulator

   (NOTE: Supply current should equal battery voltage.)

2. Check field voltage

   (NOTE: Field circuit voltage should equal battery voltage.)

3. Replace voltage regulator if steps B1 and B2 check satisfactory

   (NOTE: On models using a field relay, the relay must be tested for proper operation before replacing the voltage regulator.)

CHARGING SYSTEM
UNIT V

JOB SHEET #8--TEST INTERNAL TYPE VOLTAGE REGULATOR ON VEHICLE

I. Tools and equipment

  A. D.C. volt-ammeter

  B. Basic hand tool set

  C. Carbon pile rheostat

  D. Engine tachometer

II. Procedure

  A. Clean battery terminals

  B. Check battery specific gravity

  (NOTE: Specific gravity should be above 1.200 to allow proper regulator checks.)

  C. Check alternator drive belt tension and adjust as necessary

  D. Check all charging system wiring for defects and all terminal connections for cleanliness and tightness

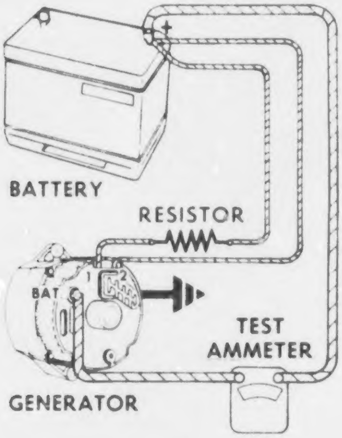
  (NOTE: If all the above steps are satisfactory, check the alternator with the following procedure.)

  E. Disconnect battery ground cable

JOB SHEET #8

F. Connect an ammeter in series at the BAT terminal of the alternator (Figure 1)

FIGURE 1

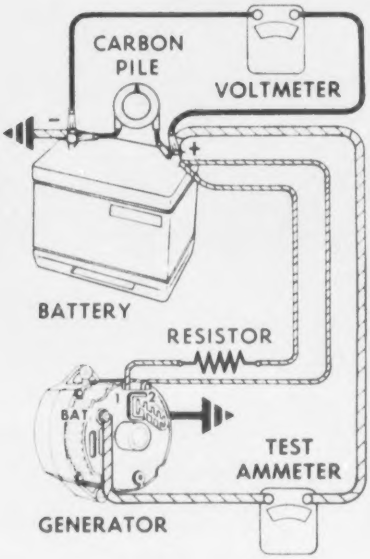

+
BATTERY
RESISTOR
BAT
1
2
TEST
AMMETER
GENERATOR

G. Reconnect battery ground cable

H. Turn on radio, windshield wipers, lights at high beam, and blower motor at high speed

I. Connect a carbon pile rheostat across the battery (Figure 2)

FIGURE 2


CARBON
PILE
VOLTMETER
-
+
BATTERY
RESISTOR
BAT
1
2
TEST
AMMETER
GENERATOR

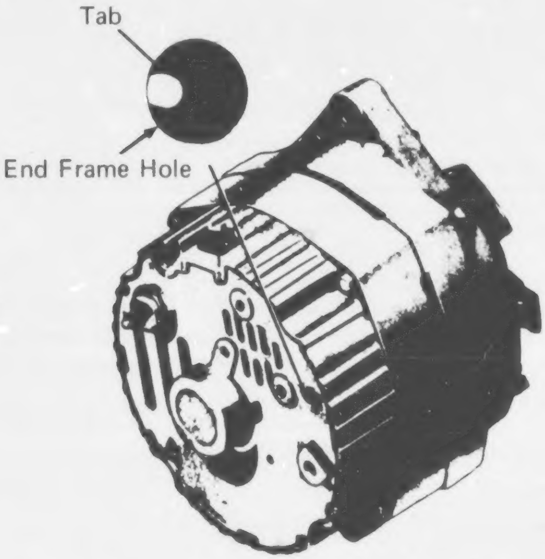
JOB SHEET #8

J. Operate engine at moderate speed and adjust the carbon pile rheostat as required to obtain maximum current output

(NOTE: If ampere output is within 10 percent of rated output, the alternator and regulator are not defective.)

K. Ground the alternator field winding tab by inserting a screwdriver in the test hole on the rectifier end frame if ampere output is not within 10 percent of rated output (Figure 3)

Figure 3



(CAUTION: Tab is within 3/4 inch [19.05 mm] of the casting surface. Do not force screwdriver deeper into the end frame; severe damage to the alternator could result.)

L. Operate engine at moderate speed and adjust carbon pile rheostat to obtain maximum current output

(NOTE: If current output is within 10 percent of rated output, replace the voltage regulator. If current output is not within 10 percent of rated output, remove alternator and bench test field windings, rectifier, and stator.)

CHARGING SYSTEM
UNIT V

TEST

NAME ________________________________ SCORE ______________

1. Write the purpose of the charging system.

____

____

____

2. Match the terms on the right to the correct definitions.

_____a. Stator winding with a positive and negative diode

_____b. Device that will allow current to flow in one direction and will block current in the opposite direction

_____c. Unit of measure used in expressing the rate of current flow in a circuit

_____d. Maximum D.C. amperage an alternator can produce

_____e. Circuit in which a wire is broken or disconnected

_____f. Unit of electrical pressure or force that will move a current of one ampere through a resistance of one ohm

_____g. Unit of measure used to indicate the amount of resistance to the flow of electricity in a given circuit

_____h. Group of diodes that convert alternating current to direct current

_____i. Circuit in which a wire touches ground, causing the current to flow to ground instead of through the circuit

_____j. Wire touching another wire and providing a shorter path for current to flow

1. Ampere
2. Volt
3. Ohm
4. Diode
5. Short circuit
6. Open circuit
7. Grounded circuit
8. Rectifier
9. Phase
10. Rated output

3. Match the charging system components on the right to the correct purposes.

_____a. Indicates a *no charge* condition in the charging system

_____b. Measures the rate of current flow

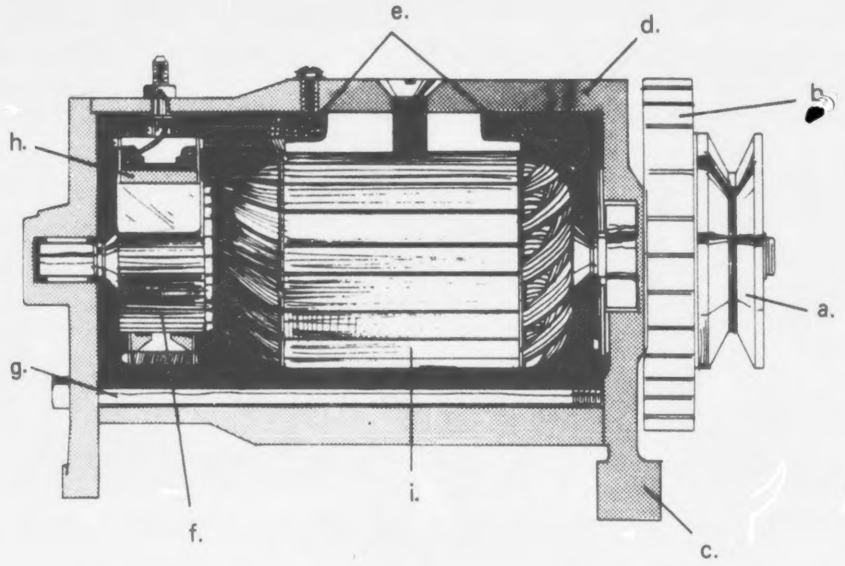
_____c. Supplies electrical power for starting and for operating the electrical system during slow generator speeds or heavy electrical load

_____d. Supplies electricity to the battery and the electrical system when driven mechanically by the engine

_____e. Controls generator voltage and current output

1. Battery
2. Ammeter
3. Regulator
4. Generator or alternator
5. Indicator light

4. Identify the parts of the generator below by writing the correct names in the blanks.



a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

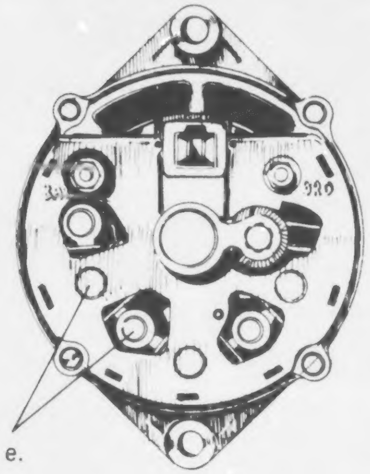
f. ____________________

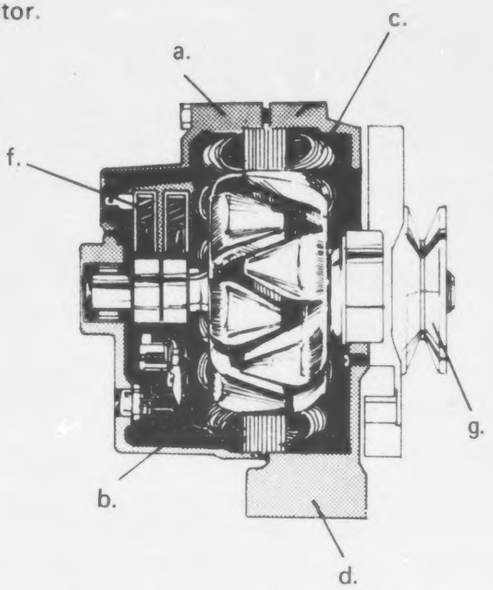
g. ____________________

h. ____________________

i. ____________________

5. Identify the parts of the alternator.





a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

g. ____________________

6. Distinguish between an alternator and a generator by placing an "A" in front of the statements relating to an alternator and a "G" in front of the statements relating to a generator.

_____a. Rotates the armature windings inside the field

_____b. Rectifies the current through the use of a segmented commutator and brushes

_____c. Rotates the field inside the stationary windings

_____d. Rectifies the A.C. current to D.C. with a series of diodes

7. List two advantages of an alternator over a generator.

a. ____

____

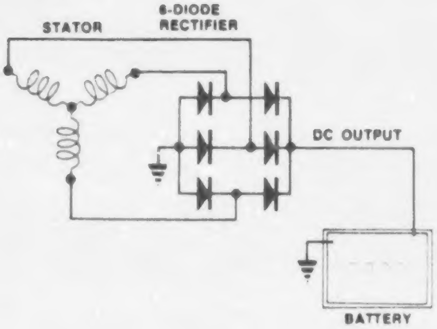
b. ____

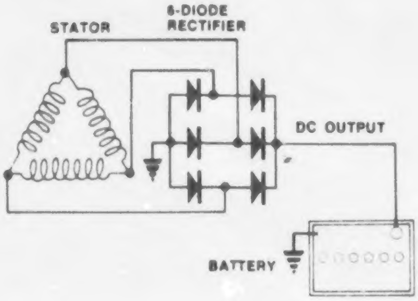
____

8. Explain why an alternator produces more current at low speed than a generator.

9. Discuss the construction of the stator.

10. Identify the following two types of stator windings.

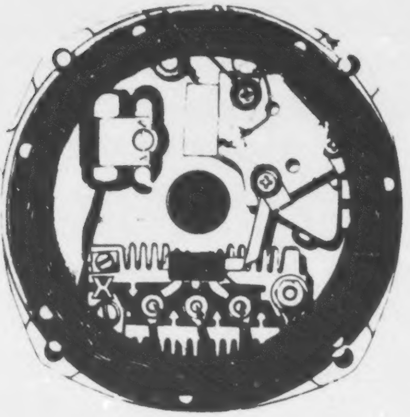

STATOR
6-DIODE RECTIFIER
DC OUTPUT
BATTERY


STATOR
6-DIODE RECTIFIER
DC OUTPUT
BATTERY

a. ____________________ b. ____________________

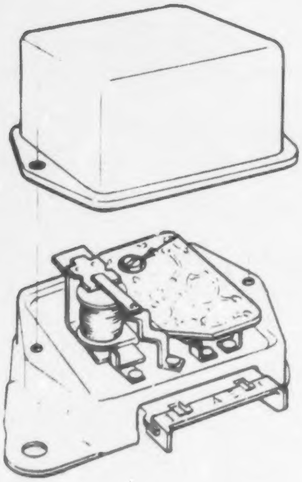
11. Describe the current and voltage regulation in the alternator.

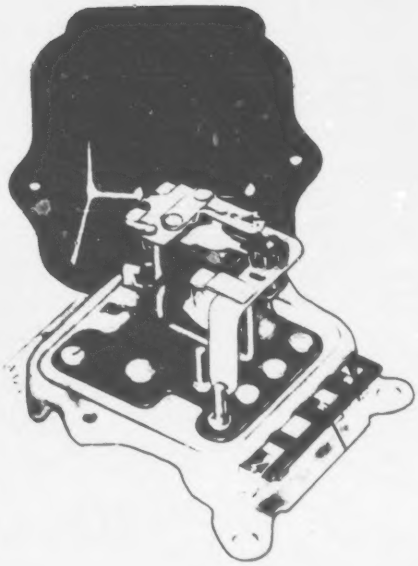
12. Identify the following types of voltage regulators for alternators.



a. ____________________

b. ____________________





c. ____________________

13. Demonstrate the ability to:

    a. Remove and replace a generator.

    b. Disassemble, check, and reassemble a generator.

    c. Remove and replace an alternator.

    d. Disassemble, check, and reassemble an alternator.

    e. Test charging circuit resistance of an alternator.

    f. Test current output of an alternator.

    g. Test external type voltage regulator.

    h. Test internal type voltage regulator on vehicle.

    (NOTE: If the above activities have not been accomplished prior to the test, ask the instructor when they should be completed.)

CHARGING SYSTEM
UNIT V

ANSWERS TO TEST

1. To recharge the battery and maintain a supply of electrical current to meet the operating needs of the automobile

2.
   a. 9
   b. 4
   c. 1
   d. 10
   e. 6
   f. 2
   g. 3
   h. 8
   i. 7
   j. 5

3.
   a. 5
   b. 2
   c. 1
   d. 4
   e. 3

4.
   a. Pulley
   b. Fan
   c. Drive end frame
   d. Generator housing
   e. Field coils
   f. Commutator
   g. Through bolt
   h. Brush
   i. Armature

5.
   a. Slip ring end frame
   b. Rotor assembly
   c. Stator assembly
   d. Drive end frame
   e. Diodes
   f. Brush assembly
   g. Pulley

6. a. G c. A

b. G d. A

7. a. Produces higher output at low engine speeds

b. Requires less maintenance because of its simple construction

8. Explanation should include:

An alternator has more pole pieces than a generator so that many more magnetic lines of force are cut during one revolution of the rotor

9. Discussion should include:

a. The core is constructed of a predetermined number of stamped steel plates riveted together to form a laminated core

b. Stator has three different coil windings equally spaced around the core

c. Stator is electrically connected to the rectifier assembly containing one positive and one negative diode rectifier for each winding

10. a. Wye connected

b. Delta connected

11. Description should include:

a. Current capacity is regulated by the number of turns of wire in each phase

b. Voltage is regulated by controlling the current flow in the rotor field

12. a. Electronic or solid state internal

b. Transistorized

c. Electromechanical

13. Performance skills evaluated to the satisfaction of the instructor

CHASSIS WIRING
UNIT VI

UNIT OBJECTIVE

After completion of this unit, the student should be able to read a wiring diagram and test for short, open, and grounded circuits. The student should be able to locate electrical problems using a systematic approach and make wiring repairs. This knowledge will be evidenced through demonstration and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with chassis wiring to the correct definitions.
2. Identify common electrical symbols.
3. Identify electrical terminals and connectors.
4. Name the types of bulbs used in an automobile.
5. Label the parts of a sealed beam lamp.
6. Distinguish between hot and ground circuits.
7. List facts about voltage drop.
8. List facts about current draw.
9. Distinguish between single and two-wire circuits.
10. Identify`electrical test instruments.
11. Arrange in order steps in diagnosing electrical problems.
12. Select from a list characteristics of a wiring diagram.
13. Label the parts of a typical circuit identification code.
14. Read a wiring diagram.
15. Troubleshoot an electrical circuit.
16. Demonstrate the ability to:
    a. Install a soldered terminal.
    b. Install a solderless terminal.
    c. Splice a wire (solder method).

d. Splice a wire (solderless method).

e. Remove and replace a bulb.

f. Align headlights.

g. Remove and replace a sealed beam.

h. Remove and replace a headlight switch.

i. Remove and replace a power window motor.

j. Test circuit with voltmeter.

k. Test electrical motor current draw.

CHASSIS WIRING
UNIT VI

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

  A. Provide student with objective sheet.

  B. Provide student with information, assignment, and job sheets.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information sheet and assignment sheets.

  F. Obtain wiring diagrams from major auto manufacturers.

  G. Compare diagram identification codes from various manufacturers.

  H. Explain how to read a wiring diagram using Transparencies 8-11 before completing assignment sheets.

  I. Demonstrate the procedures outlined in the job sheets.

  J. Give test.

II. Unit references:

  A. Crouse, William H. *Automotive Mechanics.* 7th ed. New York: McGraw-Hill Book Co., 1975.

  B. Crouse, William H. *Automotive Electrical Equipment*. 8th ed. New York: McGraw-Hill Book Co., 1976.

  C. *Ford Electrical Diagnosis Manual*. Dearborn, Michigan: Ford Motor Co., 1976.

  D. *Chevrolet Service Manual*. Detroit, Michigan: Chevrolet Motor Div./General Motors Corp., 1977.

  E. *Chrysler, Plymouth, Dodge Chassis Service Manual.* Detroit, Michigan: Chrysler Corp., 1976.

  F. *Ford Service Manual.* Dearborn, Michigan: Ford Motor Co., 1975-76.

CHASSIS WIRING
UNIT VI

INFORMATION SHEET

I. Terms and definitions

(NOTE: Some of the following terms may be a review from earlier units.)

A. Voltage--Unit of measurement of the electrical pressure in a circuit; measured with a voltmeter

B. Amperage--Unit of measurement of the amount of electrical current passing a given point; measured with an ammeter

C. Resistance--Opposition to current flow in a circuit; measured in ohms

D. Conductor--Material which carries electrical current from the source to the load and back to the source

E. Insulator--Material that prevents electrical current from transferring from one conductor to another

F. Circuit--Continuous path along a conductor through which electrical current can flow from a source, through a load, and back to the source

G. Series circuit--Current has only one path through circuit (Transparency 1)

H. Parallel circuit--Current has two or more paths through which to travel through circuit (Transparency 1)

I. Series-parallel circuit--Combination of both series and parallel circuits (Transparency 2)

J. Open circuit--Conductor (wire) is broken or connections are poor and will not support current flow

K. Terminal--Some kind of screw, post, pin, or socket at the end of a wire or cable

L. Switch--Mechanical device used to open and close a circuit

M. Polarity--Collective term applied to the positive and negative ends of a magnet; direction of current flow in a circuit

N. Bulb--Electrical device that produces light

(NOTE: Bulbs are rated by the candle power produced by a given voltage. All bulbs are identified by a number which classifies each bulb by candle power and amperage.)

INFORMATION SHEET

O. Filament--Fine coiled tungsten wires which are vacuum sealed in a glass chamber

(NOTE: When heated, the filament glows and produces light.)

P. Single filament--Bulb with only one filament

Q. Double filament--Bulb with two filaments

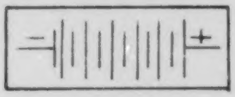
R. Wiring harness--Any system of wires which are taped together for electrical distribution throughout the vehicle

S. Short or short circuit--Defect which permits current to take a shorter path instead of following the prescribed path

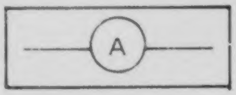
T. Ground--Negative or uninsulated side of a circuit in a vehicle

II. Electrical symbols

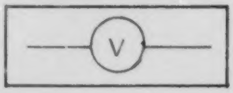
A. 12-volt battery



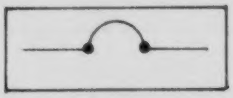
B. Ammeter



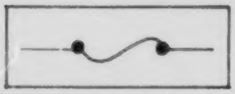
C. Voltmeter



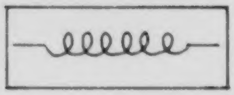
D. Circuit breaker



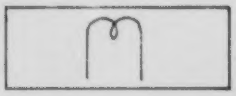
E. Fuse



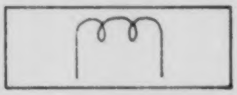
F. Coil



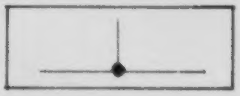
G. Single-filament lamp



H. Double-filament lamp

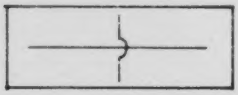


I. Connected conductor

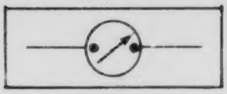


INFORMATION SHEET

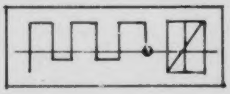
J. Crossover conductor



K. Gauge (temperature or fuel)



L. Voltage limiter (for instrument panel)



III. Types of electrical terminals and connectors (Transparency 3)

   A. Solder type terminals

      1. Ring
      2. Spade
      3. Roll

   B. Solderless type terminals

      1. Ring
      2. Spade
      3. Roll

   C. Connectors

      1. Blade
      2. Bullet

IV. Types of bulbs used in automobiles (Transparency 4)

   A. Single filament

   B. Double filament

V. Parts of a sealed beam

   A. Locating lug (Transparency 5)

   B. Electrical terminals

   C. Filaments

   D. Reflector

   E. Aiming lugs

INFORMATION SHEET

F. Lens

G. Number indicating type of filament

(NOTE: Single-filament lamps are used for dual head lamp systems and for high beam only.)

VI. Differences between hot and ground circuits (Transparency 6)

A. Hot circuit--That part of a circuit from battery positive terminal to the load which usually includes circuit protector, switch, and other control mechanisms

B. Ground circuit--That part of the circuit from the load back to the negative terminal of the battery

VII. Facts about voltage drop

A. Voltage drop occurs when electricity flows through a resistance

B. Resistance can be the load, a resistor used for motor speed control or lamp brightness, or a poor connection in either hot or ground circuit

C. Voltage drop can be measured directly by connecting the voltmeter across the component with the circuit operating

D. Voltage drop adds up when connected in series with the load

VIII. Facts about current draw

A. Current draw cannot be read in an open circuit because there is no current flow

B. Current draw is highest with no resistance

C. Current draw reduces as resistance is added in series

D. Current draw increases as loads are added in parallel

E. Current draw test is useful to determine if a motor is operating against a mechanical bind

IX. Single- and two-wire circuits (Transparency 6)

A. Single-wire circuit--Circuit in which a wire is used on the hot side of the circuit and the vehicle chassis is used for the ground side of the circuit

(NOTE: Most of the circuits in an automobile are single-wire circuits.)

B. Two-wire circuit--Circuit which uses a wire on the hot side and a wire for the ground side of the circuit

INFORMATION SHEET

X. Instruments used in testing automobile electrical circuits (Transparency 7)

  A. Continuity test light

  B. Continuity test light, self-powered

  C. Jumper wire

  D. Voltmeter

  E. Ammeter

  F. Ohmmeter

XI. Steps in diagnosis of electrical problems

  A. Determine the problem

  B. Trace the circuit

  C. Isolate the problem

  D. Test systematically

  E. Verify the problem

  F. Repair

  G. Test the repair

XII. Characteristics of a wiring diagram (Transparencies 8-11, Assignment Sheets #1 and #2)

(NOTE: Reading a wiring diagram is something like reading a road map. A road map shows routes that connect one place with another; a wiring diagram shows routes, too. The lines represent actual wires, which are identified by numbers much like highways are identified on a road map.)

  A. Lines represent wires

  B. Wires have identification numbers

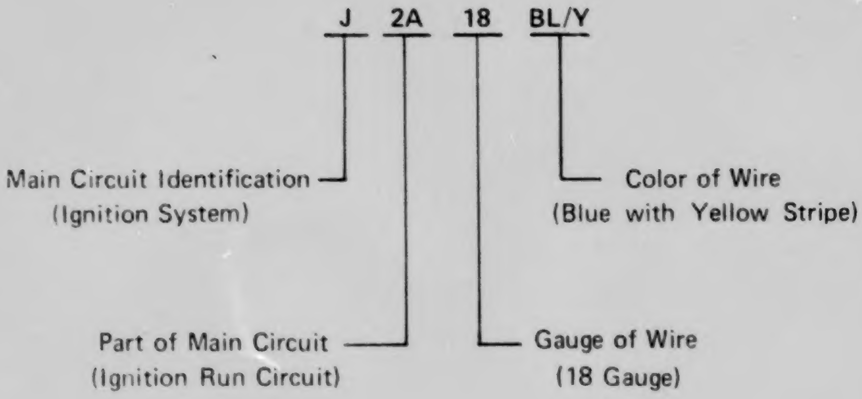
  C. Wires are color-coded

  D. Components are represented by symbols

  E. Symbols indicate locations of circuits or components in the vehicle

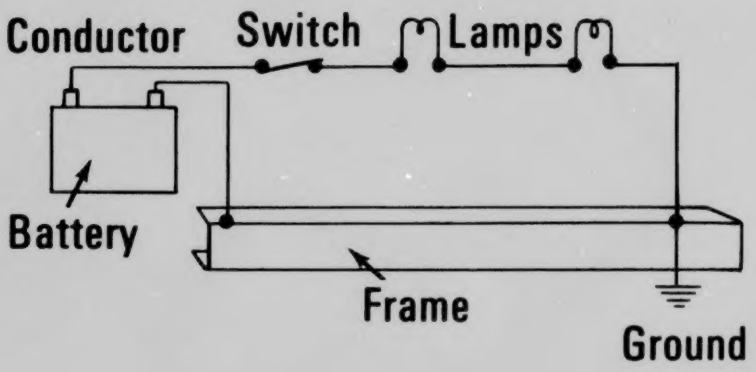
INFORMATION SHEET

XIII. Parts of a typical circuit identification code

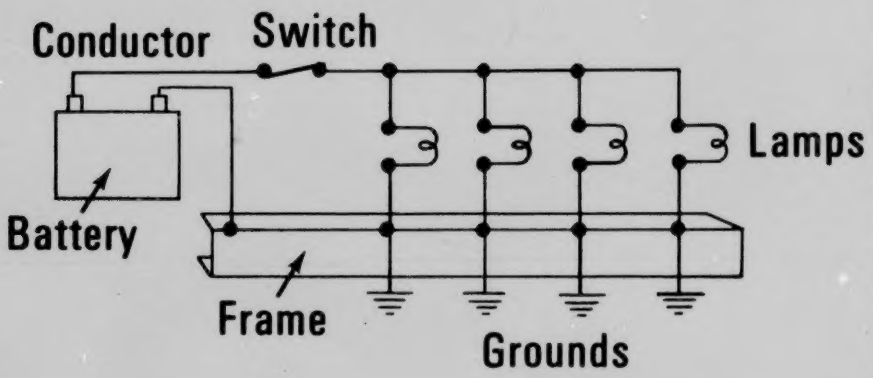

J 2A 18 BL/Y
Main Circuit Identification
(Ignition System)
Color of Wire
(Blue with Yellow Stripe)
Part of Main Circuit
(Ignition Run Circuit)
Gauge of Wire
(18 Gauge)

Electrical Circuits

SERIES CIRCUIT

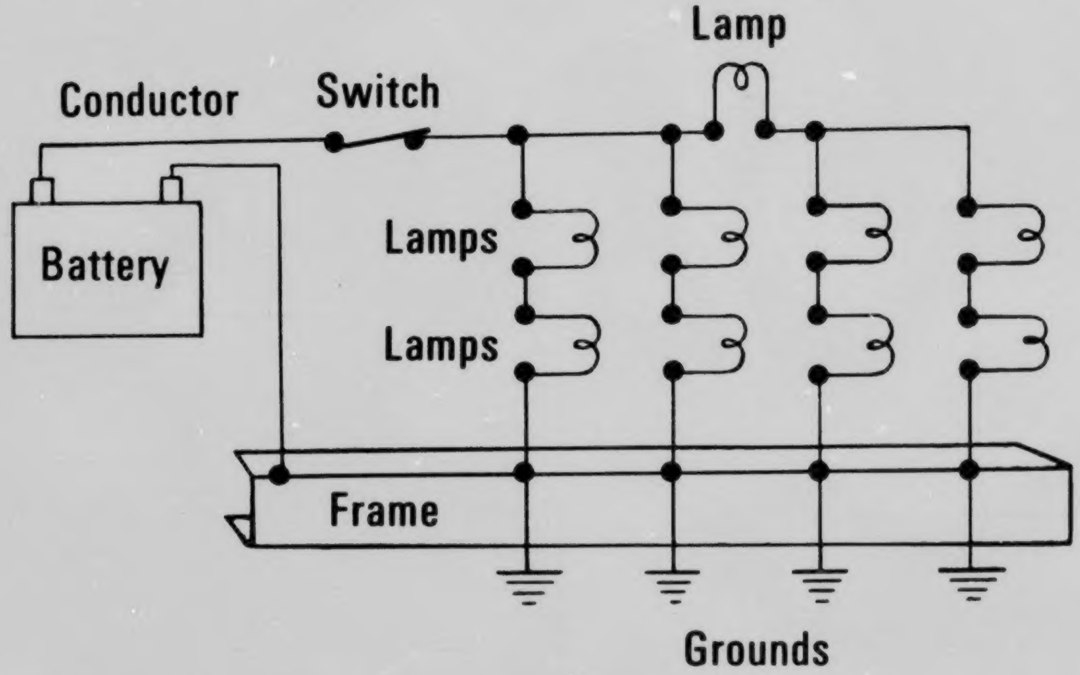

Conductor
Switch
Lamps
Battery
Frame
Ground

PARALLEL CIRCUIT


Conductor
Switch
Lamps
Battery
Frame
Grounds

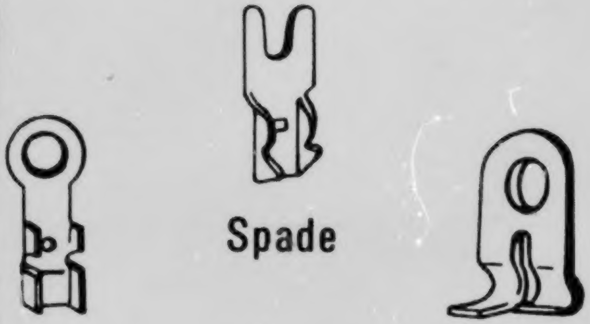
Electrical Circuits

(CONTINUED)


Lamp
Conductor
Switch
Battery
Lamps
Lamps
Frame
Grounds

SERIES-PARALLEL CIRCUIT

Terminals and Connectors

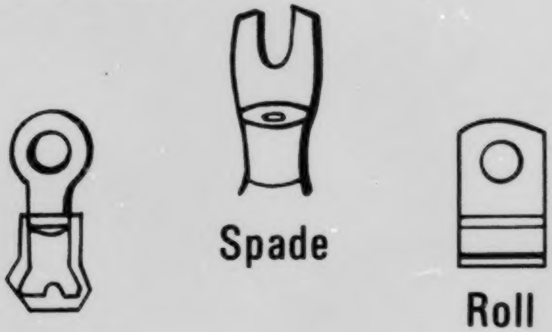


Spade

Ring

Roll

SOLDER TYPE TERMINALS

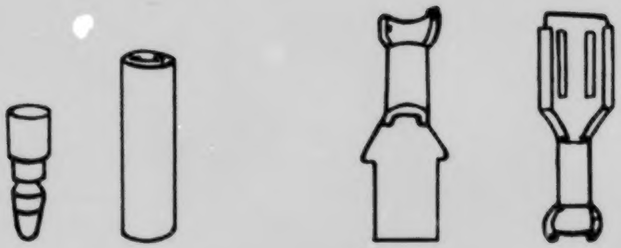


Spade

Roll

Ring

SOLDERLESS TYPE TERMINALS

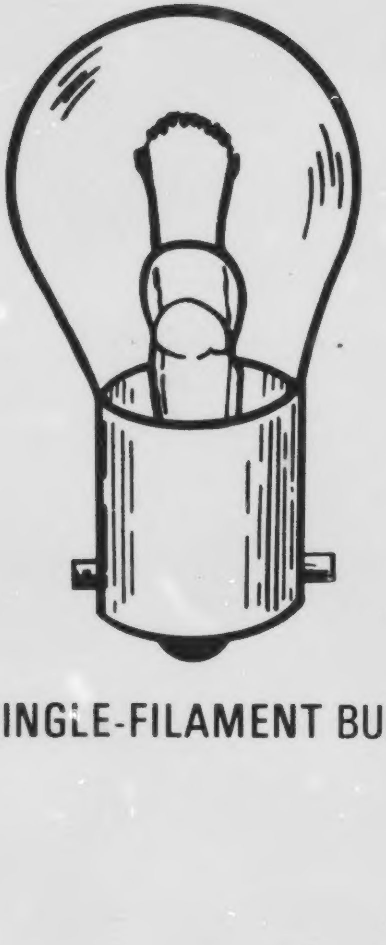


Bullet

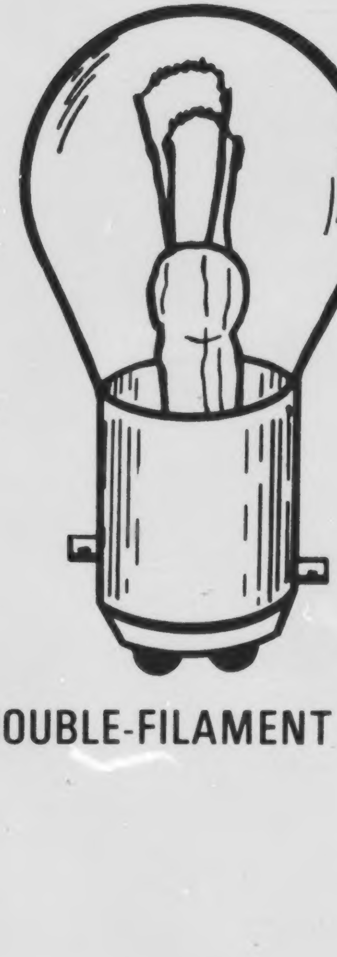
Blade

CONNECTORS

Bulb

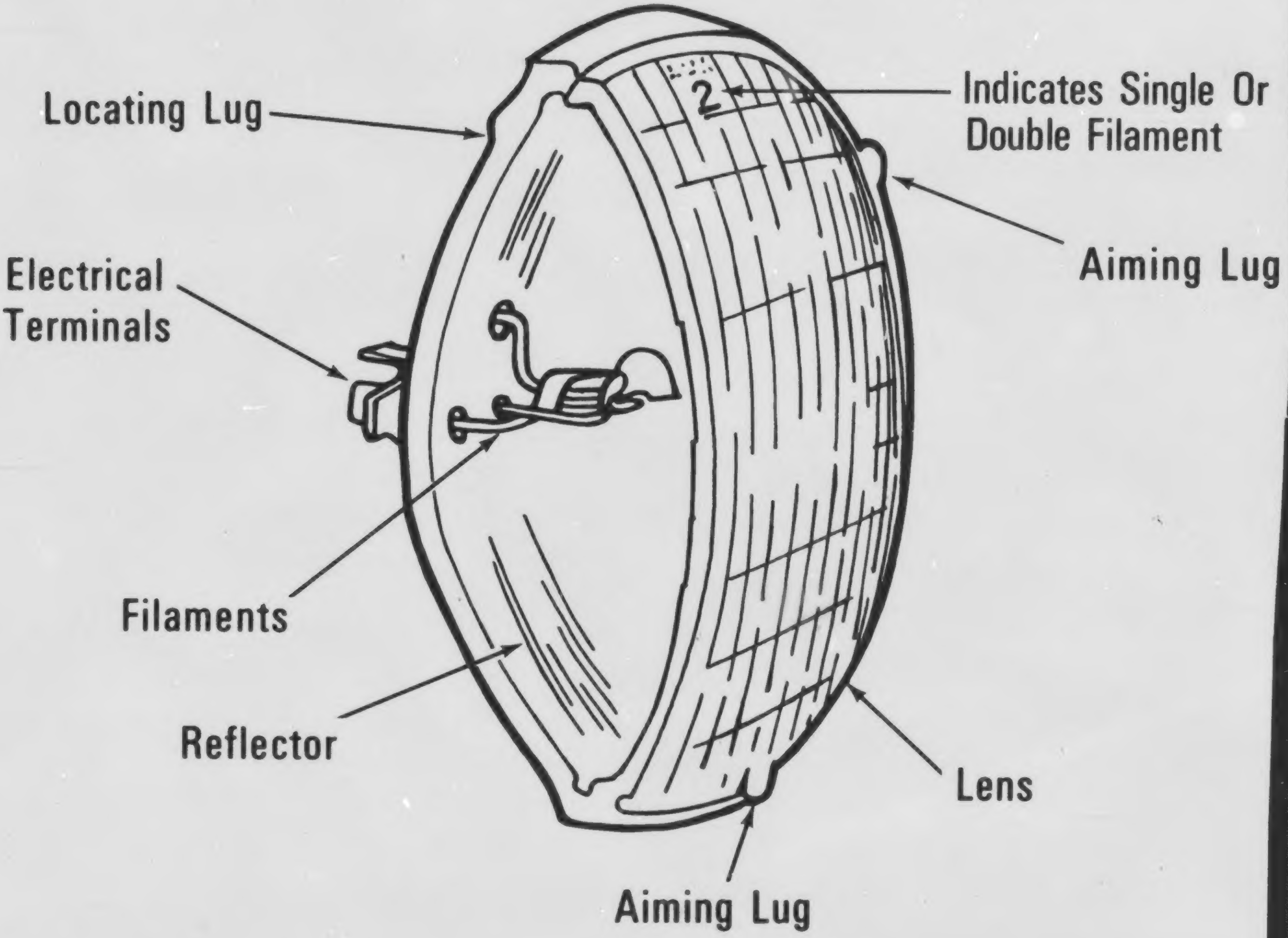


SINGLE-FILAMENT BULB



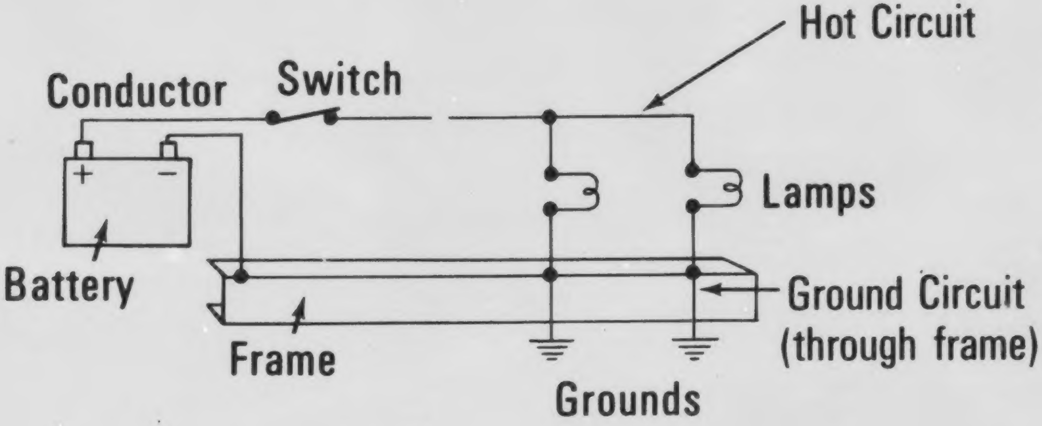
DOUBLE-FILAMENT BULB

Sealed Beam Lamp

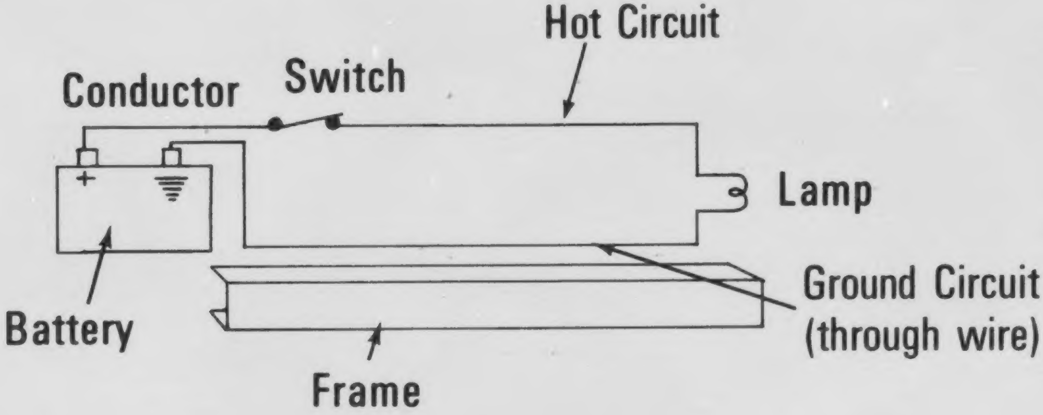

Locating Lug
Indicates Single Or Double Filament
2
Aiming Lug
Electrical Terminals
Filaments
Reflector
Lens
Aiming Lug

Single and Two-Wire Circuits

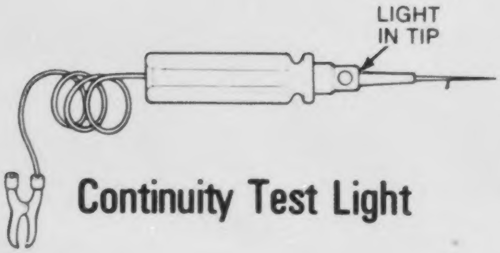
Single Wire Circuit


Hot Circuit
Conductor
Switch
+
−
Lamps
Battery
Ground Circuit
(through frame)
Frame
Grounds

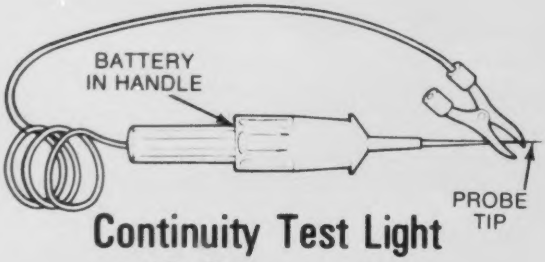
Two-Wire Circuit


Hot Circuit
Conductor
Switch
+
Lamp
Ground Circuit
(through wire)
Battery
Frame

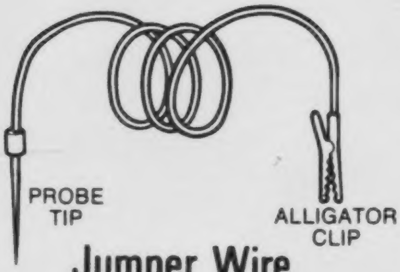
Instruments Used In Testing Electrical Circuits


LIGHT IN TIP

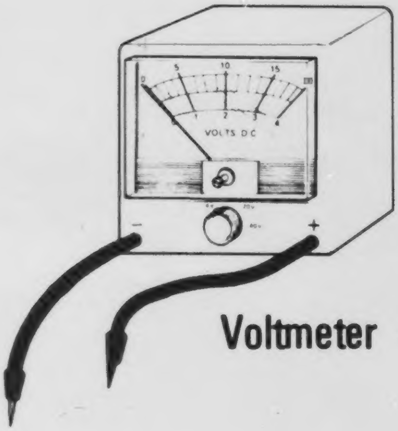
Continuity Test Light


BATTERY IN HANDLE
PROBE TIP

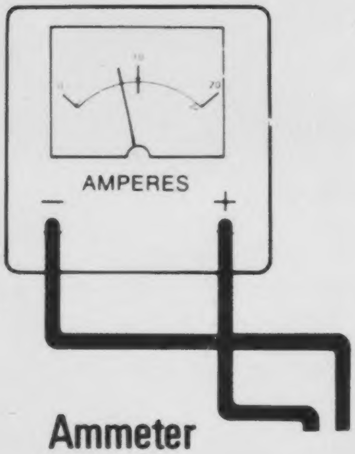
Continuity Test Light (Self-Powered)


PROBE TIP
ALLIGATOR CLIP

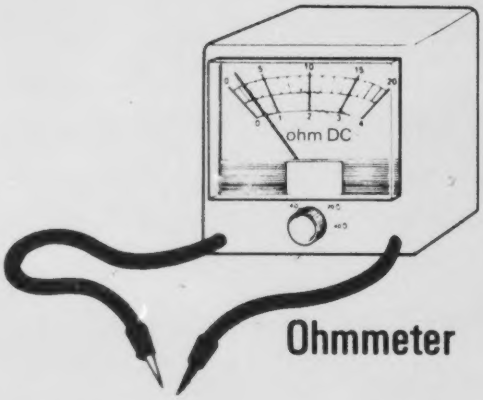
Jumper Wire


0
5
10
15
VOLTS DC
−
+

Voltmeter

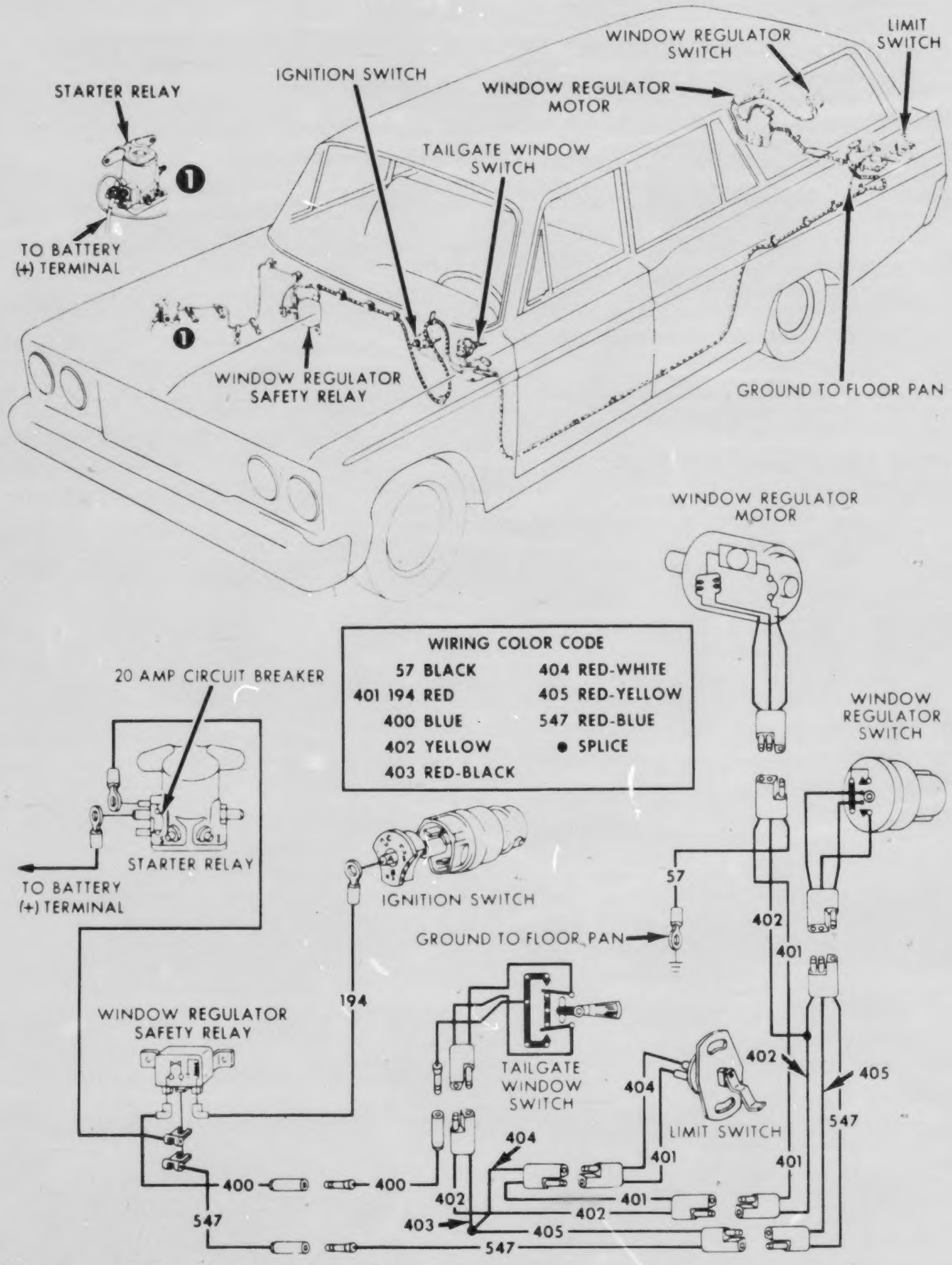

10
20
AMPERES
−
+

Ammeter


0
5
10
15
20
ohm DC

Ohmmeter

Typical Automotive Circuit

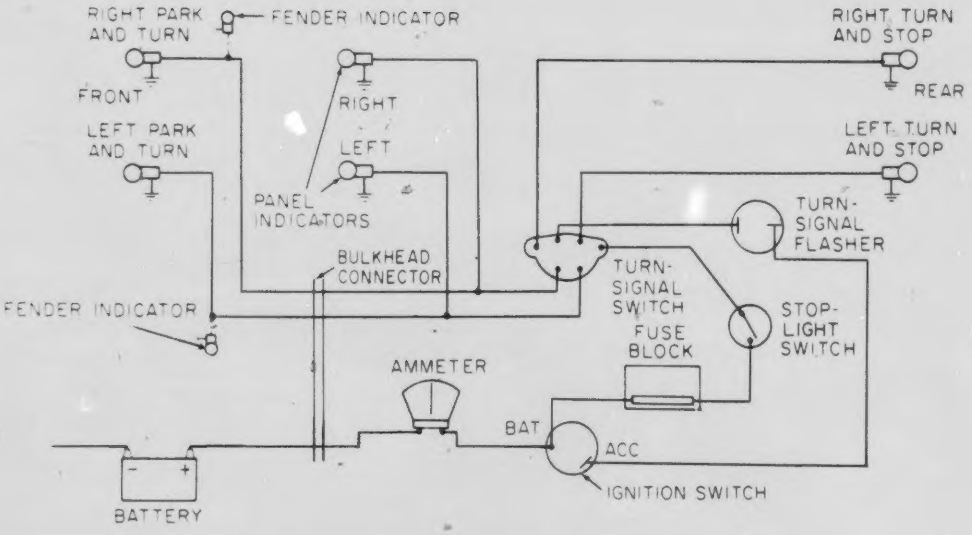

STARTER RELAY
❶
TO BATTERY (+) TERMINAL
IGNITION SWITCH
TAILGATE WINDOW SWITCH
WINDOW REGULATOR MOTOR
WINDOW REGULATOR SWITCH
LIMIT SWITCH
❶
WINDOW REGULATOR SAFETY RELAY
GROUND TO FLOOR PAN
WINDOW REGULATOR MOTOR
20 AMP CIRCUIT BREAKER
WINDOW REGULATOR SWITCH
STARTER RELAY
TO BATTERY (+) TERMINAL
IGNITION SWITCH
57
GROUND TO FLOOR PAN
402
401
194
WINDOW REGULATOR SAFETY RELAY
TAILGATE WINDOW SWITCH
402
404
405
LIMIT SWITCH
547
404
401
401
400
400
402
401
547
403
402
405
547

WIRING COLOR CODE

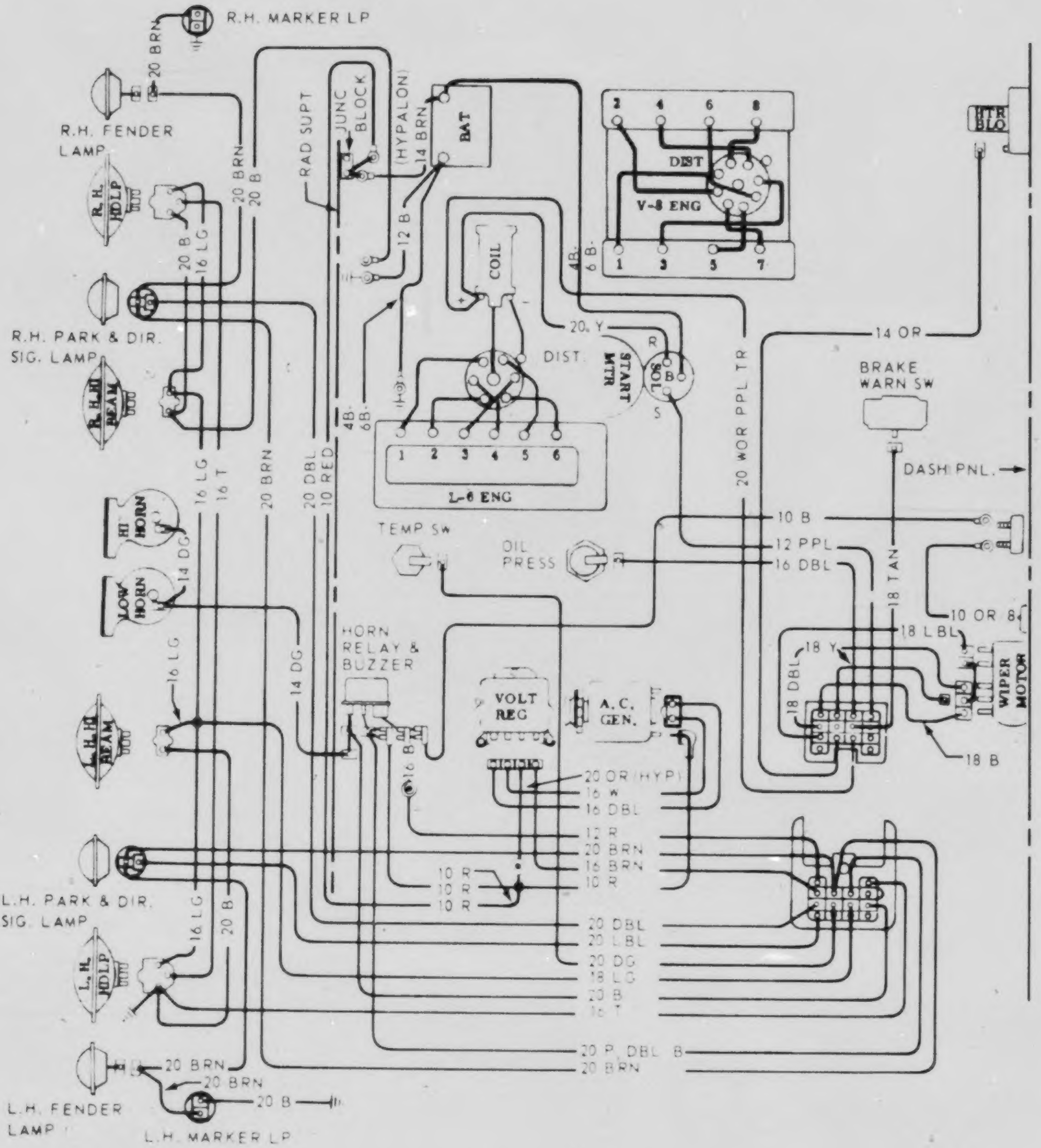
57 BLACK	404 RED-WHITE
401 194 RED	405 RED-YELLOW
400 BLUE	547 RED-BLUE
402 YELLOW	● SPLICE
403 RED-BLACK	

(Courtesy of Ford Motor Company)

Typical Signal Light Wiring Diagram

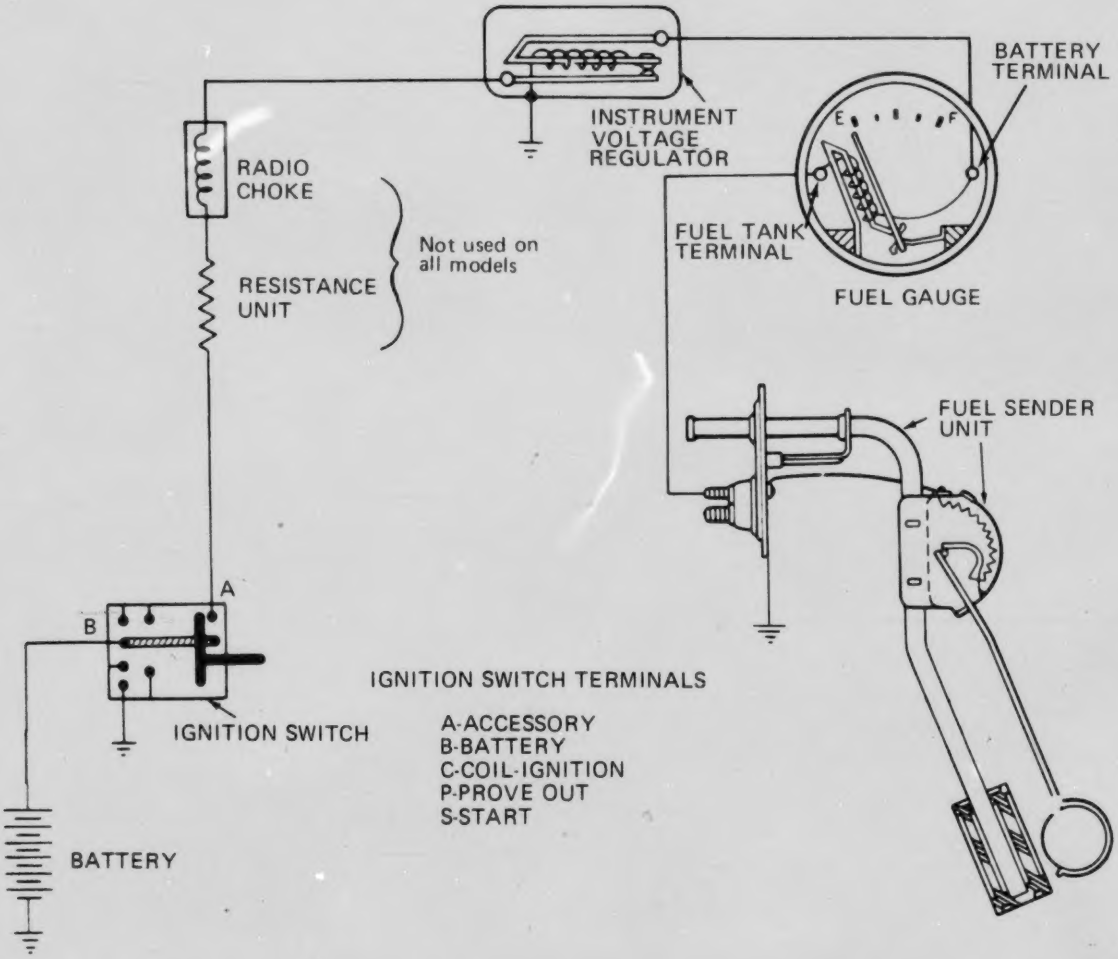

RIGHT PARK AND TURN
FENDER INDICATOR
FRONT
RIGHT
LEFT
LEFT PARK AND TURN
PANEL INDICATORS
RIGHT TURN AND STOP
REAR
LEFT TURN AND STOP
TURN-SIGNAL FLASHER
BULKHEAD CONNECTOR
TURN-SIGNAL SWITCH
FENDER INDICATOR
STOP-LIGHT SWITCH
FUSE BLOCK
AMMETER
BAT
ACC
IGNITION SWITCH
BATTERY

Typical Engine Compartment Wiring Diagram


R.H. MARKER LP
20 BRN
R.H. FENDER LAMP
R.H. HDLP
20 BRN
20 B
RAD SUPT
JUNC BLOCK
(HYPALON)
14 BRN
BAT
20 B
16 LG
12 B
R.H. PARK & DIR. SIG. LAMP
R.H. HI BEAM
COIL
DIST
V-8 ENG
2 4 6 8
1 3 5 7
4B
6B
20 Y
DIST.
START MTR
SOL
R
B
S
4B
6B
1 2 3 4 5 6
L-6 ENG
16 LG
16 T
20 BRN
20 DBL
10 RED
20 WOR PPL TR
14 OR
HTR BLO
BRAKE WARN SW
DASH PNL.
HI HORN
14 DG
LOW HORN
TEMP SW
OIL PRESS
10 B
12 PPL
16 DBL
18 TAN
10 OR
18 LBL
18 Y
18 DBL
WIPER MOTOR
18 B
16 LG
14 DG
HORN RELAY & BUZZER
VOLT REG
A.C. GEN.
L.H. HI BEAM
16 B
20 OR (HYP)
16 W
16 DBL
12 R
20 BRN
16 BRN
10 R
10 R
10 R
10 R
L.H. PARK & DIR. SIG. LAMP
16 LG
20 B
20 DBL
20 LBL
20 DG
18 LG
20 B
16 T
L.H. HDLP
20 P, DBL B
20 BRN
20 BRN
20 BRN
20 B
L.H. FENDER LAMP
L.H. MARKER LP

(Courtesy of Chevrolet Motor Division of General Motors Corporation)

Typical Gauge Circuit

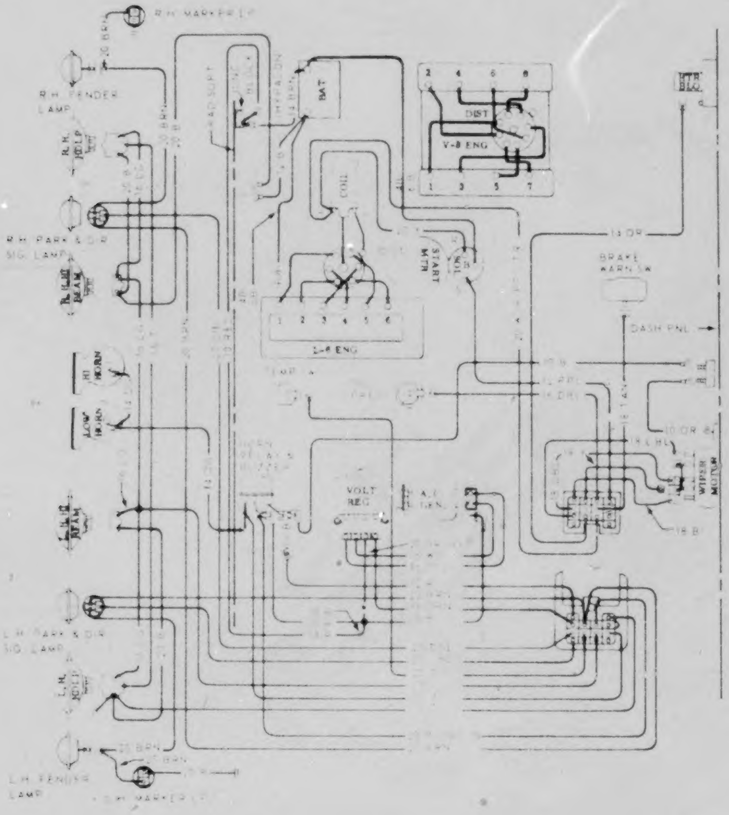

INSTRUMENT VOLTAGE REGULATOR
BATTERY TERMINAL
E
F
RADIO CHOKE
RESISTANCE UNIT
Not used on all models
FUEL TANK TERMINAL
FUEL GAUGE
FUEL SENDER UNIT
A
B
IGNITION SWITCH
IGNITION SWITCH TERMINALS
A-ACCESSORY
B-BATTERY
C-COIL-IGNITION
P-PROVE OUT
S-START
BATTERY

Schematic wiring circuit of a thermostatic fuel-gauge indicator system of the type using a variable-resistance tank unit.

CHASSIS WIRING
UNIT VI

ASSIGNMENT SHEET #1--READ A WIRING DIAGRAM

Use the wiring diagram to complete the questions below.


R.H. MARKER LP
20 BRN
R.H. FENDER LAMP
R.H. HDLP
R.H. PARK & DIR SIG. LAMP
HI HORN
LOW HORN
BAT
DIST
V-8 ENG
COIL
START MTR
SOL
L-6 ENG
14 OR
BRAKE WARN SW
DASH PNL
10 OR
WIPER MOTOR
18 B
VOLT REG
A.C. GEN
L.H. PARK & DIR SIG. LAMP
L.H. HDLP
20 BRN
L.H. FENDER LAMP
L.H. MARKER LP

1. List the wire size and color for the following components.

	Gauge of Wire	Color of Wire
a. Temperature sender switch		
b. Oil pressure sender switch		
c. Alternator battery wire		
d. Headlight ground wire		
e. Heater blower motor feed wire		

ASSIGNMENT SHEET #1

2. Trace the horn feed wire from dash panel to horns by marking the circuit with a pencil.

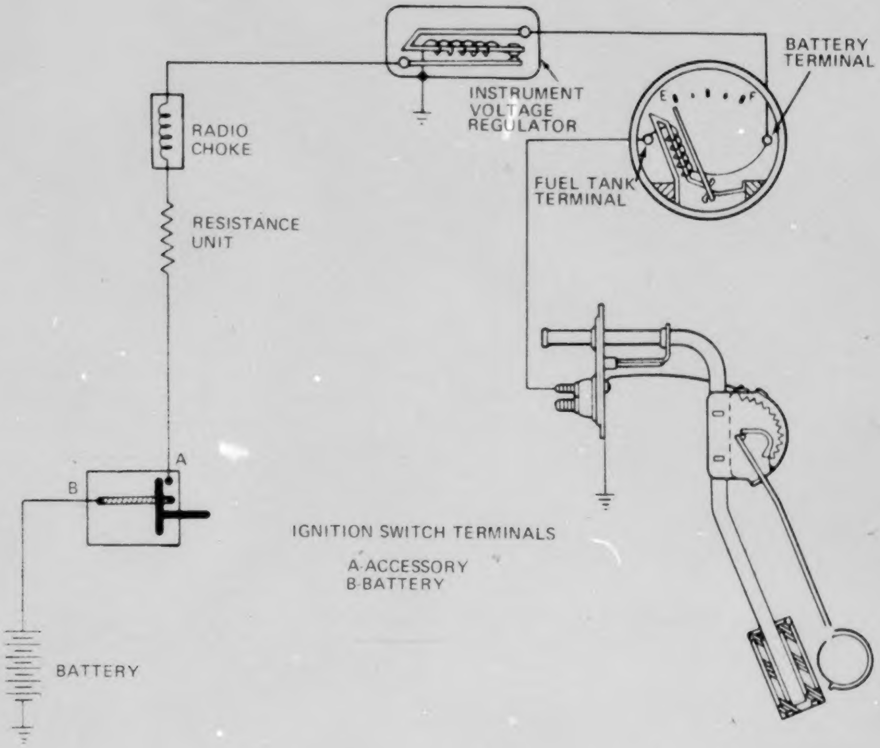
3. Indicate the name of the wires on the diagram designated by 4B or 6B.

____

CHASSIS WIRING
UNIT VI

ASSIGNMENT SHEET #2--TROUBLESHOOT AN ELECTRICAL CIRCUIT

Use the wiring diagram below to answer the following questions about failures in the circuit.


BATTERY TERMINAL
INSTRUMENT VOLTAGE REGULATOR
RADIO CHOKE
E
F
FUEL TANK TERMINAL
RESISTANCE UNIT
A
B
IGNITION SWITCH TERMINALS
A-ACCESSORY
B-BATTERY
BATTERY

1. Fuel gauge registers Empty with any level of fuel.

   Tests indicate:

   a. There is a steady voltage at the battery terminal of the fuel gauge

   b. Connecting the fuel sender unit wire to a good ground makes gauge read on the Full mark

   Conclusion: ____

   ____

ASSIGNMENT SHEET #2

2. Fuel gauge registers Empty with any level of fuel.

Tests indicate:

a. There is a steady voltage at the battery terminal of the fuel gauge

b. Connecting the fuel sender unit wire to a good ground does not have any effect on the fuel gauge

Conclusion: ____

____

CHASSIS WIRING
UNIT VI

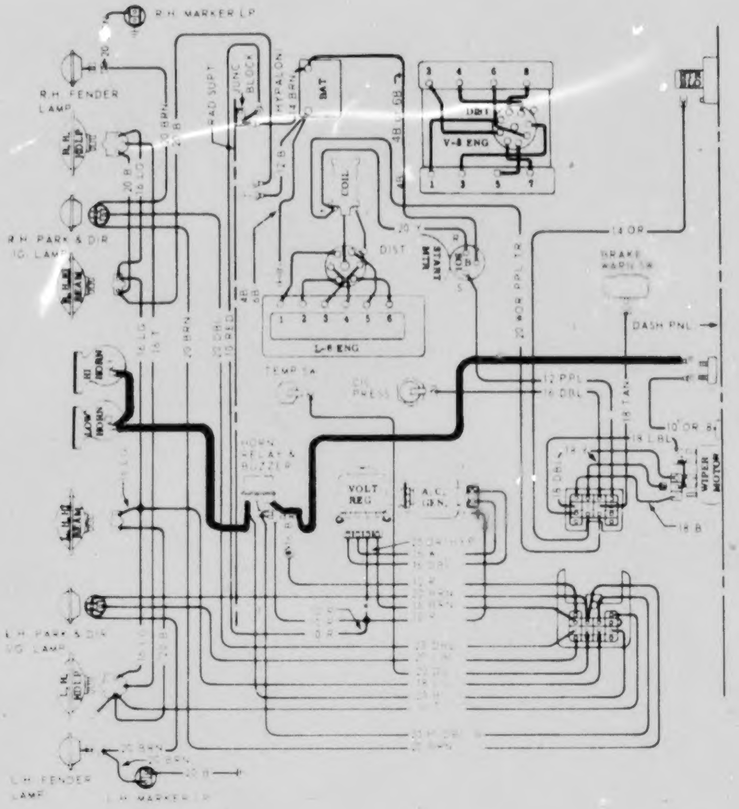
ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1.

a.	20 gauge	Dark green
b.	16 gauge	Dark blue
c.	10 gauge	Red
d.	20 gauge	Black
e.	14 gauge	Orange

2.


R.H. MARKER LP
R.H. FENDER LAMP
R.H. HDLP
R.H. PARK & DIR IG. LAMP
R.H. HDLP
HI HORN
LOW HORN
L.H. HDLP
L.H. PARK & DIR SIG. LAMP
L.H. HDLP
L.H. FENDER LAMP
L.H. MARKER LP
RAD SUPT
JUNC BLOCK
HYPALON
14 BRN
BAT
COIL
DIST
START MTR
SOL
V-8 ENG
L-6 ENG
TEMP SW
OIL PRESS
HORN RELAY & BUZZER
VOLT REG
A.C. GEN.
BRAKE WARN SW
DASH PNL
WIPER MOTOR
20 BRN
20 B
16 LG
16 T
20 BRN
20 DBL
10 RED
12 B
4B
6B
20 Y
20 OR PPL TR
14 OR
12 PPL
16 DBL
18 TAN
10 OR 8
18 LBL
18 Y
16 DBL
18 B
20 BRN
20 B

3. Battery cables

Assignment Sheet #2

1. Conclusion:
   a. Fuel sender unit is not properly grounded
   b. Fuel sender unit is defective
2. Conclusion:
   a. Wire between the fuel sender unit is open
   b. Fuel gauge is defective

CHASSIS WIRING
UNIT VI

JOB SHEET #1--INSTALL A SOLDERED TERMINAL

I. Tools and equipment

   A. Soldering gun or iron

   B. Resin core solder

   C. Medium sandpaper

   D. Terminal

   E. Electrical wire

   F. Electrical tape

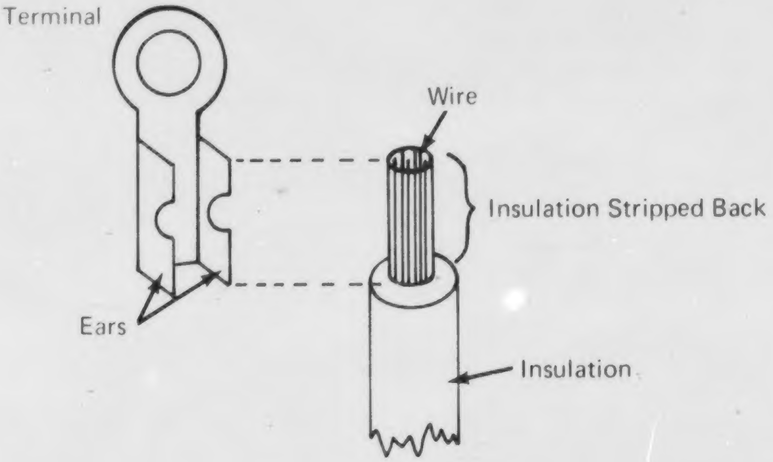
   G. Safety glasses

II. Procedure

   A. Strip end of insulation back from wire to permit installation of terminal (Figure 1)

   (NOTE: Always use the same size wire as originally used by the manufacturer.)

FIGURE 1

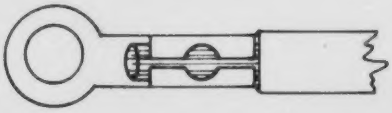

Terminal
Wire
Insulation Stripped Back
Ears
Insulation

JOB SHEET #1

B. Clean terminal with sandpaper

C. Place wire in terminal and bend ears of terminal around wire (Figure 2)

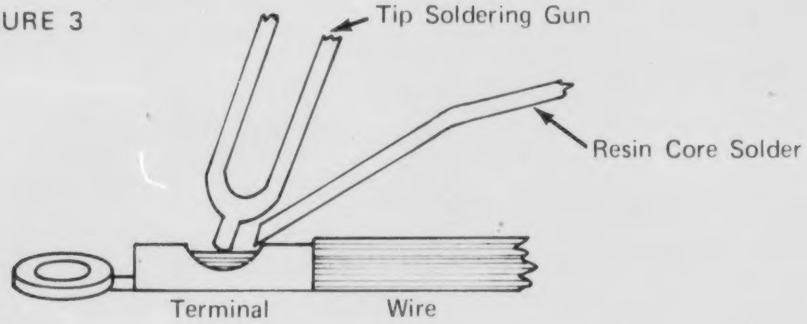
FIGURE 2



D. Solder terminal to wire (Figure 3)

(CAUTION: Use only resin core solder on electrical connections.)

FIGURE 3

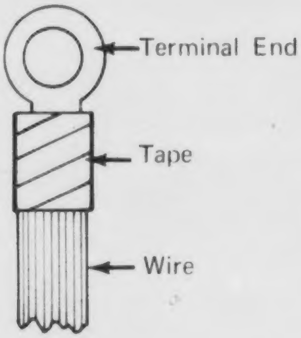

Tip Soldering Gun
Resin Core Solder
Terminal
Wire

(NOTE: Apply only enough solder to attach terminal.)

F. Tape connection (Figure 4)

(NOTE: It is only necessary to tape the connection if solder crimp area will contact or ground against a metal area.)

FIGURE 4


Terminal End
Tape
Wire

CHASSIS WIRING
UNIT VI

JOB SHEET #2--INSTALL A SOLDERLESS TERMINAL

I. Tools and equipment

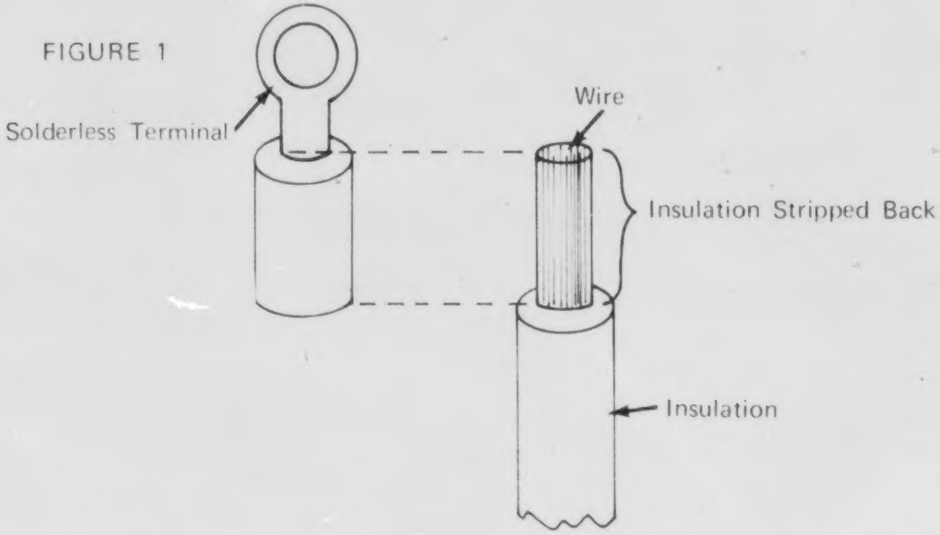
A. Crimping pliers

B. Terminal

II. Procedure

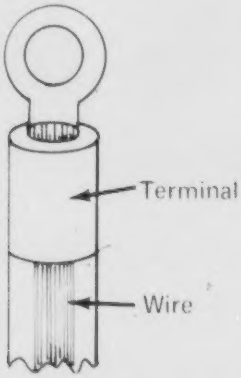
A. Strip insulation from wire to fit terminal (Figure 1)

FIGURE 1


Solderless Terminal
Wire
Insulation Stripped Back
Insulation

B. Insert wire into terminal (Figure 2)

FIGURE 2

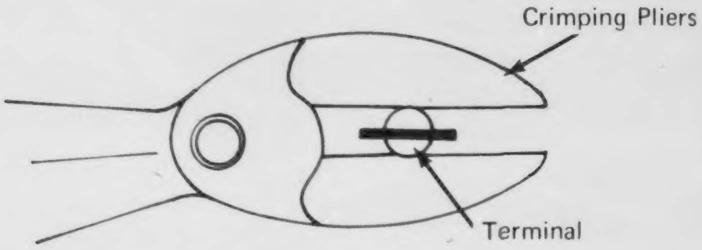

Terminal
Wire

(NOTE: Always use the terminal that fits the wire properly.)

JOB SHEET #2

C. Crimp the terminal to the wire (Figure 3)

FIGURE 3



(NOTE: Use the correct crimper opening when crimping the terminal to the wire.)

D. Connect terminal and wire to power source

(NOTE: Always use the proper size wire when making a repair.)

CHASSIS WIRING
UNIT VI

JOB SHEET #3--SPLICE A WIRE (SOLDER METHOD)

I. Tools and equipment

   A. Soldering gun or iron

   B. Electrical wire

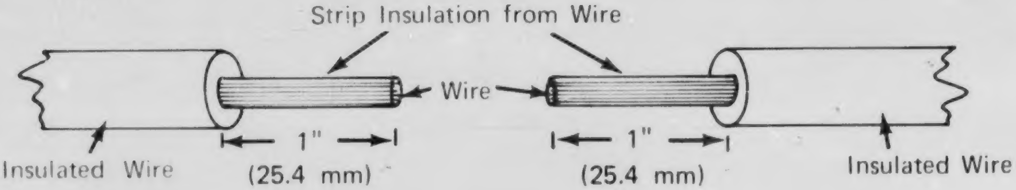
   C. Resin core solder

   D. Electrical tape

II. Procedure

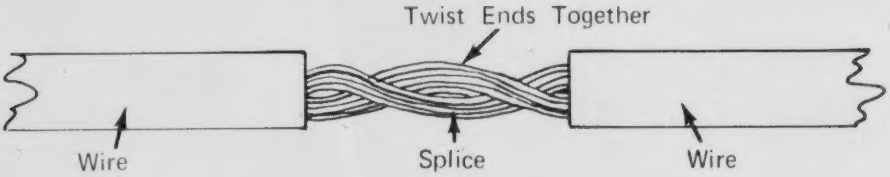
   A. Strip back insulation one inch (25.4 mm) from ends of wire (Figure 1)

FIGURE 1


Strip Insulation from Wire
Wire
Insulated Wire
1"
(25.4 mm)
1"
(25.4 mm)
Insulated Wire

   B. Twist wire ends together (Figure 2)

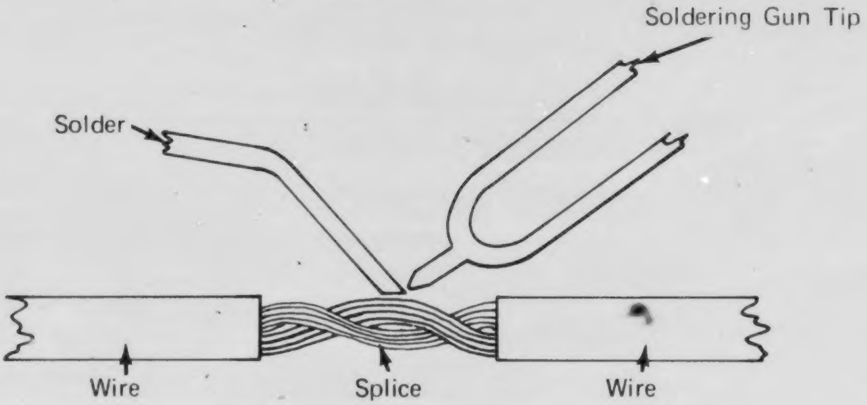
FIGURE 2


Twist Ends Together
Wire
Splice
Wire

JOB SHEET #3

C. Solder the wires (Figure 3)

FIGURE 3


Soldering Gun Tip
Solder
Wire
Splice
Wire

(NOTE: Only flow enough solder on splice to hold wire securely. Do not waste solder or build up joint. If splice has too much solder, the splice joint will break.)

D. Tape splice by wrapping neatly with electrical tape

CHASSIS WIRING
UNIT VI

JOB SHEET #4--SPLICE A WIRE (SOLDERLESS METHOD)

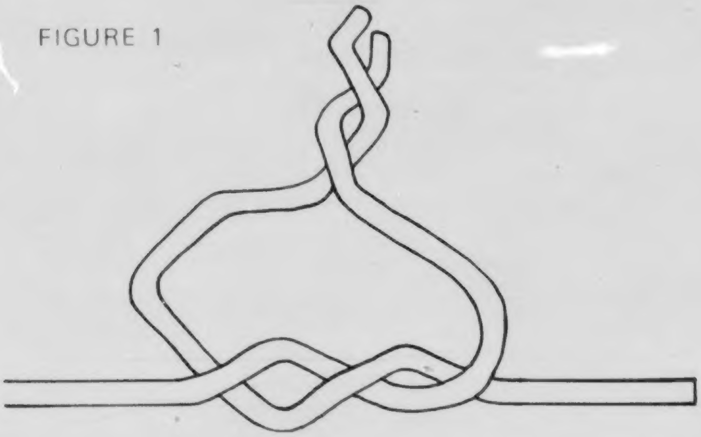
I. Tools and equipment

- A. Electrical wire
- B. Electrical tape

II. Procedure

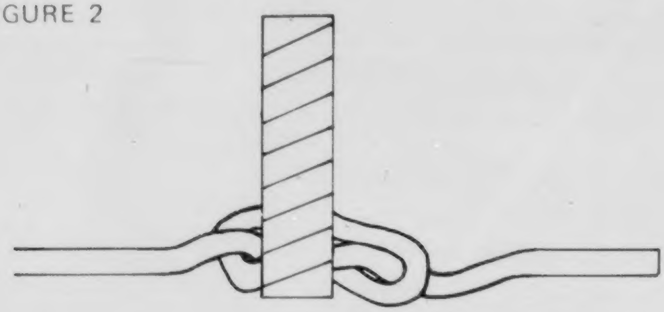
- A. Strip back insulation one inch (25.4 mm) from ends of wire
- B. Tie wire and twist ends together (Figure 1)

FIGURE 1



- C. Pull knot tight
- D. Tape splice ends of wire (Figure 2)

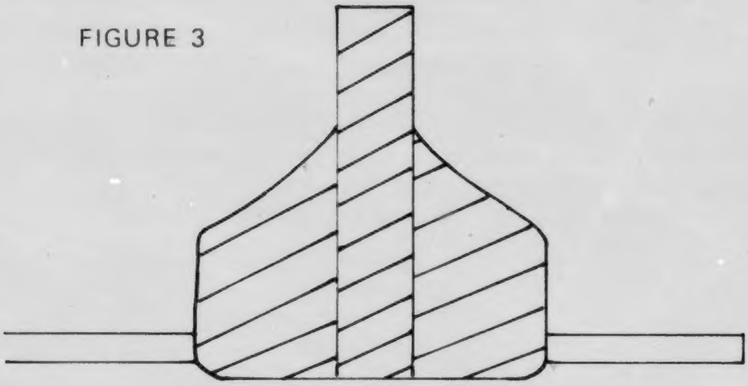
FIGURE 2



JOB SHEET #4

E. Wrap slice with tape (Figure 3)

FIGURE 3



(NOTE: By being tied in a knot, the splice cannot pull apart. Be sure to tape securely. If the elements can get to the wire splice and thus corrode the wires, an open circuit could result at the splice.)

CHASSIS WIRING
UNIT VI

JOB SHEET #5--REMOVE AND REPLACE A BULB

I. Tools and equipment

   A. Bulb pliers

   B. Standard screwdriver set

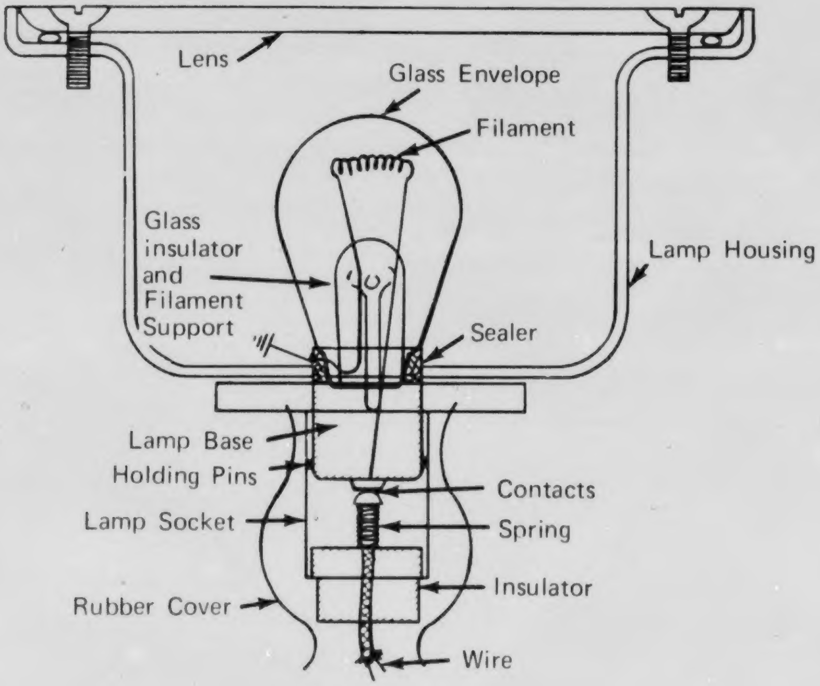
   C. Phillips screwdriver set

II. Procedure

   A. Remove lens, door, or cover from light assembly (Figure 1)

   (NOTE: Dash and interior light assemblies either twist or pull out.)

FIGURE 1


Lens
Glass Envelope
Filament
Glass insulator and Filament Support
Lamp Housing
Sealer
Lamp Base
Holding Pins
Contacts
Lamp Socket
Spring
Insulator
Rubber Cover
Wire

JOB SHEET #5

B. Remove bulb

    1. Push in on bulb
    2. Twist counterclockwise
    3. Pull bulb out of socket

C. Clean socket with sandpaper or a scuff pad or by blowing socket out with air

D. Replace bulb

    1. Push bulb in socket
    2. Turn clockwise to lock

    (NOTE: Not all bulbs are retained in this type of socket. Side marker lights just push in and pull out, and some dome and interior lights are retained by clips. Examine each light carefully. Always replace bulbs with the same number as the original.)

E. Replace lens

    1. Clean and install gasket if used
    2. Clean lens
    3. Assemble lens on light assembly

CHASSIS WIRING
UNIT VI

JOB SHEET #6--ALIGN HEADLIGHTS

I. Tools and equipment

- A. Headlight aligner
- B. Phillips screwdriver set
- C. Standard screwdriver set

II. Procedure

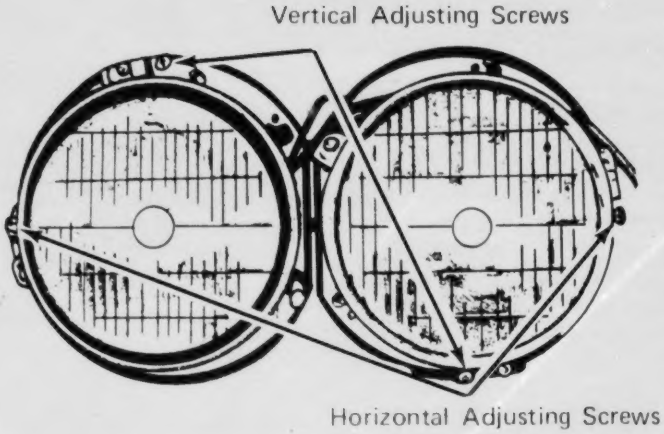
A. Attach or set up headlight alignment equipment

(CAUTION: Read manufacturer's directions carefully and install or set up alignment equipment properly.)

B. Adjust headlight (Figure 1)

1. Adjust vertical adjusting screws
2. Adjust horizontal adjusting screws

FIGURE 1


Vertical Adjusting Screws
Horizontal Adjusting Screws

CHASSIS WIRING
UNIT VI

JOB SHEET #7--REMOVE AND REPLACE A SEALED BEAM

I. Tools and equipment

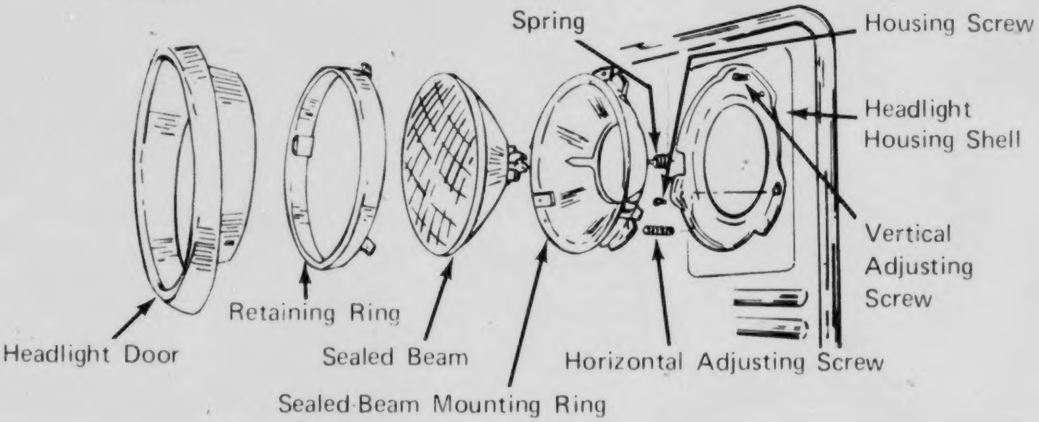
   A. Standard screwdriver set

   B. Phillips screwdriver set

II. Procedure

   A. Remove headlight door, retaining ring, and sealed beam (Figure 1)

FIGURE 1


Spring
Housing Screw
Headlight Housing Shell
Vertical Adjusting Screw
Retaining Ring
Headlight Door
Sealed Beam
Horizontal Adjusting Screw
Sealed-Beam Mounting Ring

   B. Replace sealed beam

   C. Replace retaining ring

   (NOTE: On some models, the spring from the headlight housing to the headlight bucket must be attached before screws are installed. Do not stretch the spring.)

   D. Align headlights

   (NOTE: On some models, the headlight can be adjusted with the headlight door attached.)

   E. Replace headlight door

CHASSIS WIRING
UNIT VI

JOB SHEET #8--REMOVE AND REPLACE A HEADLIGHT SWITCH

I. Tools and equipment

  A. Basic hand tool set

  B. Battery cable puller

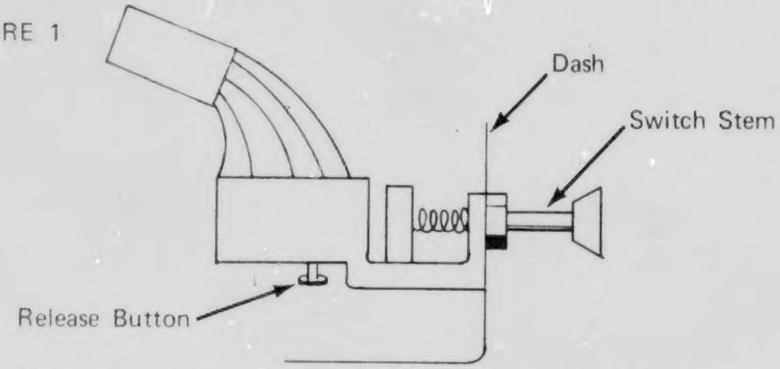
  C. Safety glasses

II. Procedure

  A. Disconnect negative or ground battery cable

  B. Remove headlight switch stem by depressing the release button and pulling out on switch stem (Figure 1)

FIGURE 1


Dash
Switch Stem
Release Button

(NOTE: Determine whether the dash trim bezel will have to be removed to provide access to the switch retaining nut. Figures 2a and 2b show two popular methods of mounting switches.)

FIGURE 2a

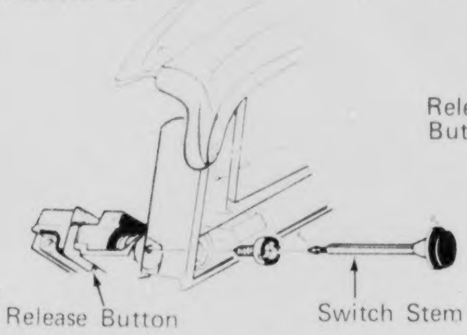
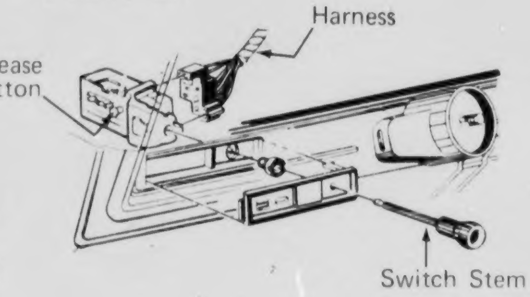

Release Button
Switch Stem

FIGURE 2b


Harness
Release Button
Switch Stem

JOB SHEET #8

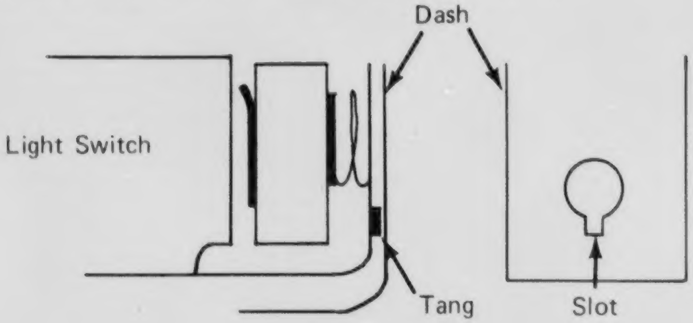
C. Remove switch using correct method for model of vehicle being repaired

1. Remove switch on models with dash trim bezel covering switch attaching nut
    - a. Remove dash trim bezel as necessary to gain access to switch retaining nut
    - b. Remove any air conditioning ducts or other equipment necessary to gain access to switch behind dash
    - c. Disconnect wiring harness connector from switch
    - d. Remove switch retaining nut
    - e. Remove switch
2. Remove switch on models with accessible switch retaining nut
    - a. Remove any air conditioning ducts or other equipment necessary to gain access to switch behind dash
    - b. Remove the switch attaching nut
    - c. Remove switch from behind dash panel
    - d. Disconnect wiring harness connector from switch

D. Install headlight switch

1. Plug wire connector into switch
2. Align switch behind dash panel with the switch hole in dash
3. Start attaching nut
4. Tighten attaching nut while positioning switch so that the aligning lug fits in the slot in the dash panel (Figure 3)

FIGURE 3



JOB SHEET #8

5. Insert switch knob into switch
6. Reconnect the ground cable

CHASSIS WIRING
UNIT VI

JOB SHEET #9--REMOVE AND REPLACE A POWER WINDOW MOTOR

I. Tools and equipment

   A. Basic hand tool set

   B. Ratchet and socket set, 1/4" drive

   C. Hex wrench set

   D. Door handle removing tool

   E. Safety glasses

   F. Weatherstrip adhesive

   G. Trim adhesive

   H. Lubricant (oil, grease)

   I. Shop towels

II. Procedure

   A. Remove door handle (Figures 1a, 1b, 1c)

FIGURE 1a

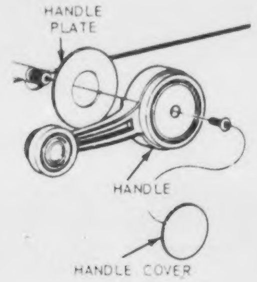

HANDLE PLATE
HANDLE
HANDLE COVER

FIGURE 1b

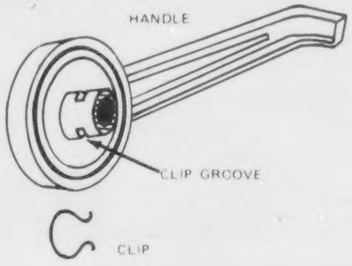
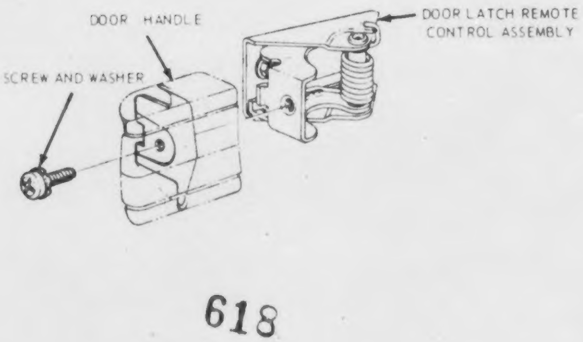

HANDLE
CLIP GROOVE
CLIP

FIGURE 1c


DOOR HANDLE
DOOR LATCH REMOTE CONTROL ASSEMBLY
SCREW AND WASHER

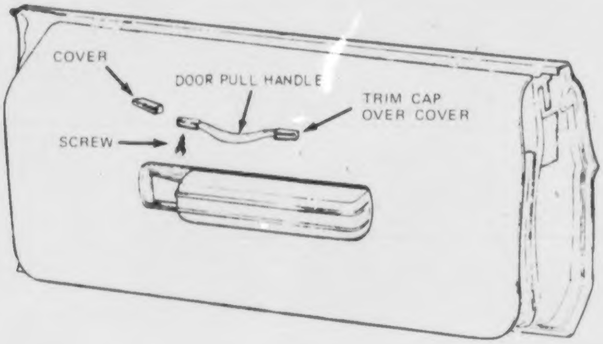
JOB SHEET #9

B. Remove arm rest

C. Remove door pull handle (Figure 2)

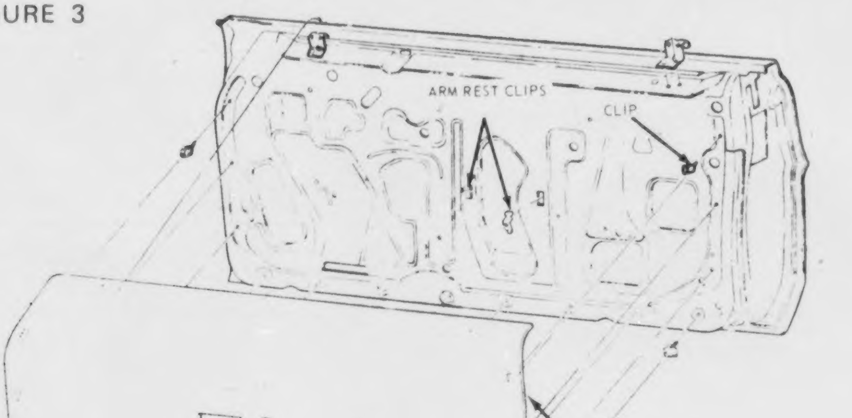
(NOTE: There is usually a screw at the end of the door pull handle. Some handles have a chrome or vinyl cap over the ends which must be removed to gain access to the screws.)

FIGURE 2


COVER
DOOR PULL HANDLE
TRIM CAP OVER COVER
SCREW

D. Remove trim panel (Figure 3)

FIGURE 3


ARM REST CLIPS
CLIP
PRY ON CLIPS TO AVOID DAMAGE TO PANEL

JOB SHEET #9

1. Remove any trim screws

2. Pry trim panel loose from clip retainers

   (NOTE: Use care not to tear clip from panel or break nails from nail-applied panel.)

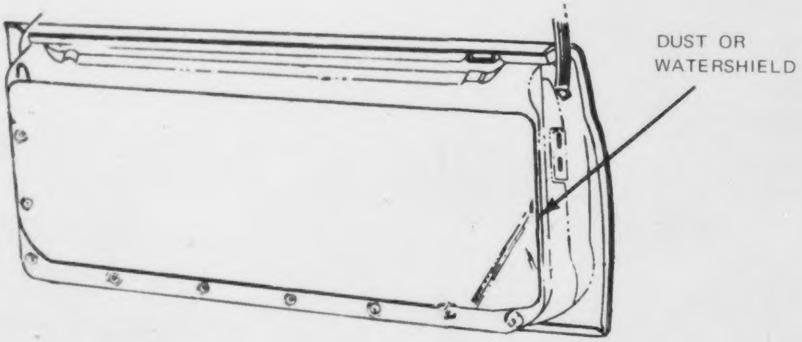
3. Disconnect electrical switch carefully

   (NOTE: Most switches are simply unplugged and remain with the door.)

E. Remove dust and water seal cover (Figure 4)

(NOTE: The cover may be plastic or paper. Remove it carefully. It must be replaced to prevent water and dust from getting into the interior of the car.)

FIGURE 4



F. Remove regulator cam rollers or bolts from sash channel

(NOTE: It may be necessary to remove door glass on some models.)

G. Disconnect the regulator motor from power source

H. Remove bolts from regulator

I. Slide regulator out of pivot channel

JOB SHEET #9

J. Remove regulator through opening in door

(NOTE: On some models, the center division channel will have to be removed to allow clearance for the regulator and motor assembly to be removed.)

(CAUTION: Regulators are spring loaded. Do not allow fingers to get caught in the arms or in the gear mechanism.)

K. Remove motor from regulator

   1. Set regulator in a vise and lock the arms to prevent spring from unloading

   2. Remove the motor

   (NOTE: If motor is bad, replace it. If the regulator is bad, repair or replace it as necessary.)

   (CAUTION: If the regulator is to be removed from the vise before the motor is reinstalled, use care because the spring tension will make the arms move violently.)

L. Replace regulator and motor assembly

   1. Install regulator in door opening

   2. Align channel pivots while sliding regulator into place

M. Align regulator mounting holes with door holes and secure with attaching bolts

N. Install regulator cam rollers or bolts in sash channel

O. Connect motor electrical wires

P. Connect window electrical switch

Q. Run window up and down and check for alignment; adjust as necessary

R. Install dust and water seal cover

S. Install door trim panel

T. Install panel retaining screws and clips

U. Install door pull handle and cover plates

V. Install arm rest

W. Install door handle

X. Check window and door for proper operation

CHASSIS WIRING
UNIT VI

JOB SHEET #10--TEST CIRCUIT WITH VOLTMETER

I. Tools and equipment

- A. Basic hand tool set
- B. Safety glasses
- C. Voltmeter
- D. Circuit to test, either on a vehicle or on a circuit board

II. Procedure

(NOTE: A voltmeter can be used to measure available voltage or voltage drop. The circuit must be under load while testing.)

A. Test battery voltage

(NOTE: Refer to Figure 1 on the following page.)

1. Turn voltmeter to highest scale
2. Connect positive voltmeter lead to positive terminal of battery
3. Connect negative voltmeter lead to negative terminal

   (NOTE: Always observe the polarity of the system when connecting a voltmeter.)

4. Turn the voltmeter selector to the scale that will make the meter pointer read in mid-scale range

   (NOTE: Set the selector to the 20-volt scale for 12-volt batteries.)

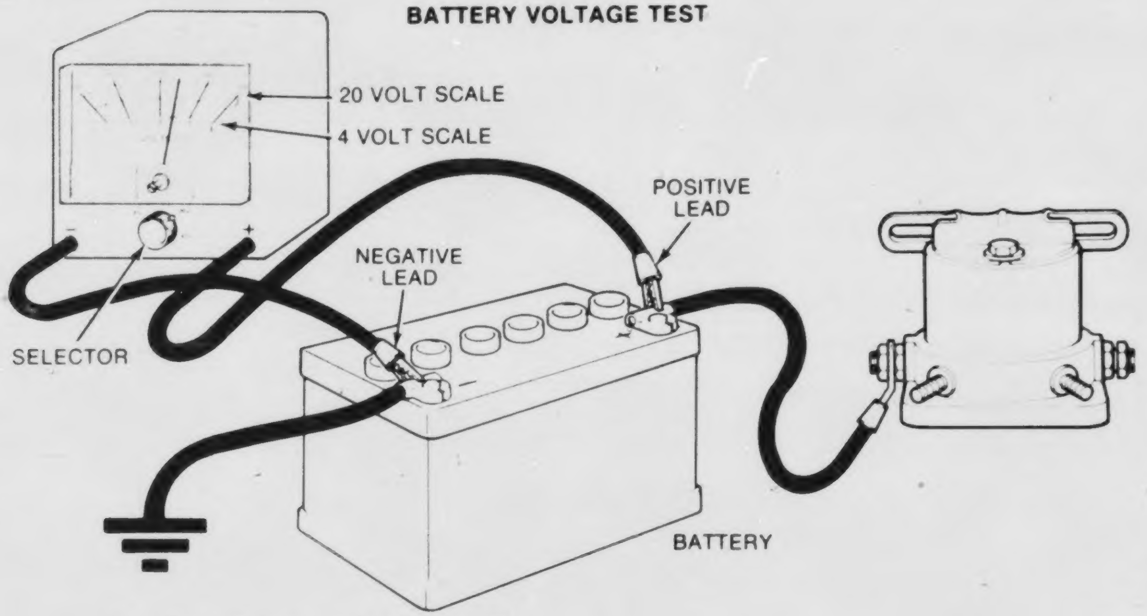
JOB SHEET #10

5. Read the voltmeter for battery voltage

   (NOTE: Less than 11.5 volts at the battery is not enough to operate the electrical system effectively.)

FIGURE 1

BATTERY VOLTAGE TEST



B. Test voltage drop (Figure 2)

(NOTE: The circuit used for this test is a typical heater or air conditioning blower circuit. In Figure 2, power is by-passing the resistors and the blower is running in high speed.)

1. Connect voltmeter across the battery terminals

2. Read battery available voltage

   (NOTE: Meter should read 12 volts.)

3. Move voltmeter positive lead to starter relay (Position 2)

   (NOTE: Voltmeter should read 12 volts.)

4. Move voltmeter lead to load side of fuse (Position 3)

   (NOTE: Voltmeter should read 12 volts. The negative voltmeter lead can be moved from battery terminal to a good ground inside the vehicle at this point.)

JOB SHEET #10

5. Move positive voltmeter lead to multi-connector at resistor pack at blower high speed feed wire (Position 4)

   (NOTE: Voltmeter should read 12 volts.)

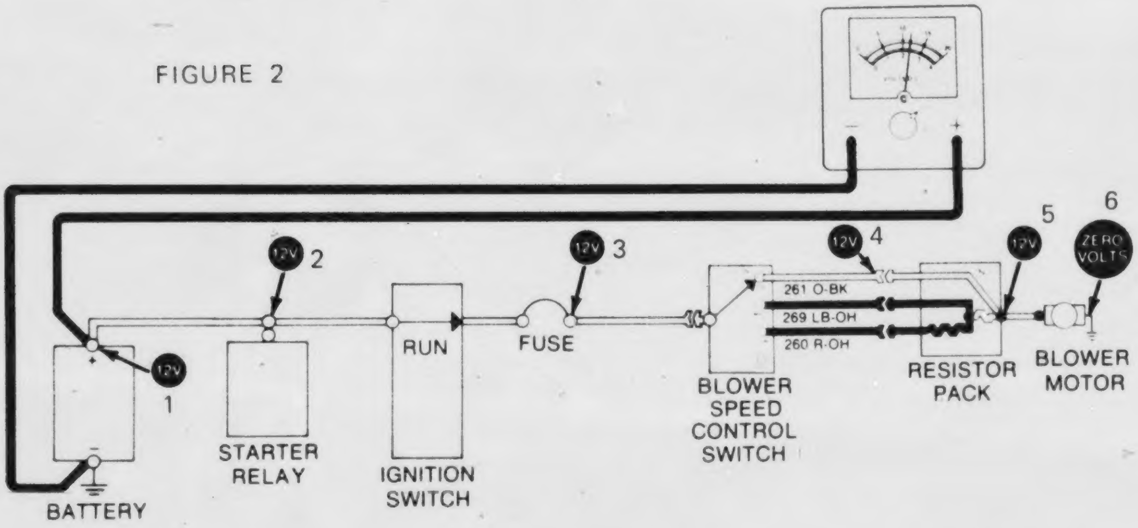
6. Move positive voltmeter lead to blower motor hot wire (Position 5)

   (NOTE: Voltmeter should read 12 volts.)

7. Move positive voltmeter lead to blower motor ground wire connections (Position 6)

   (NOTE: Voltmeter should read 0 volts.)

FIGURE 2


12V
2
12V
3
12V
4
5
12V
6
ZERO VOLTS
261 O-BK
269 LB-OH
260 R-OH
+
12V
1
−
BATTERY
STARTER RELAY
RUN
IGNITION SWITCH
FUSE
BLOWER SPEED CONTROL SWITCH
RESISTOR PACK
BLOWER MOTOR
−
+

(NOTE: Battery voltage is available at the blower motor because there is little resistance in the circuit up to this point. In practice, we would probably lose or drop maybe one-half of a volt up to this point. The blower ground reads 0 voltage, so the circuit has "dropped" or used up the full 12 volts to operate the motor.)

JOB SHEET #10

C. Test voltage drops in series (Figure 3)

(NOTE: Use the same circuit above but switch the blower switch to low speed. Current will flow through wire 260 which has two resistors in series.)

1. Connect voltmeter negative lead to a good ground
2. Connect voltmeter positive lead to blower switch feed wire (Position 1)

   (NOTE: Voltmeter should read 12 volts.)

3. Move voltmeter positive lead to wire 260 R-OH going into resistor pack (Position 2)

   (NOTE: Voltmeter should read 12 volts.)

4. Move voltmeter positive lead to resistor A (Position 3)

   (NOTE: Voltmeter should read 8 volts or a 4-volt drop.)

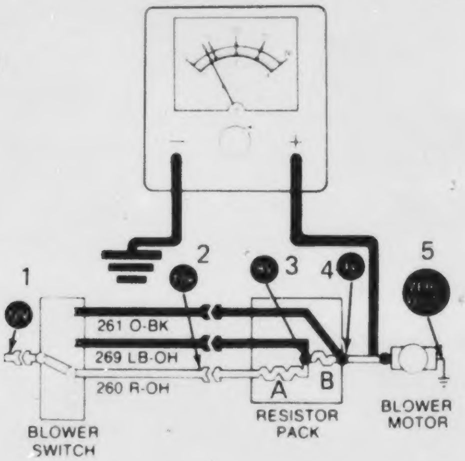
5. Move voltmeter positive lead to resistor B (Position 4)

   (NOTE: Voltmeter should read 4 volts or an additional 4-volt drop from Position 3)

6. Move voltmeter positive lead to blower motor ground (Position 5)

   (NOTE: Voltmeter reading should be "0" voltage.)

FIGURE 3



(NOTE: It is a basic law of electrical circuits that, where resistances are connected in series, the voltage drops add up to the total available voltage at the source. Also, each voltage drop will be proportional to the resistance of the component through which the electricity flows.)

CHASSIS WIRING
UNIT VI

JOB SHEET #11--TEST ELECTRICAL MOTOR CURRENT DRAW

I. Tools and equipment

   A. Basic hand tool set

   B. Ammeter

   C. Safety glasses

   D. Vehicle with similar circuit or a circuit board with similar components

II. Procedure

   (NOTE: This job sheet shows how current draw is used in diagnosing circuit problems.)

   A. Test current draw on motor

      1. Test with full battery voltage available (Figure 1)

         a. Connect ammeter in series between resistor pack and blower motor while observing correct polarity

         b. Set blower switch to the high speed position

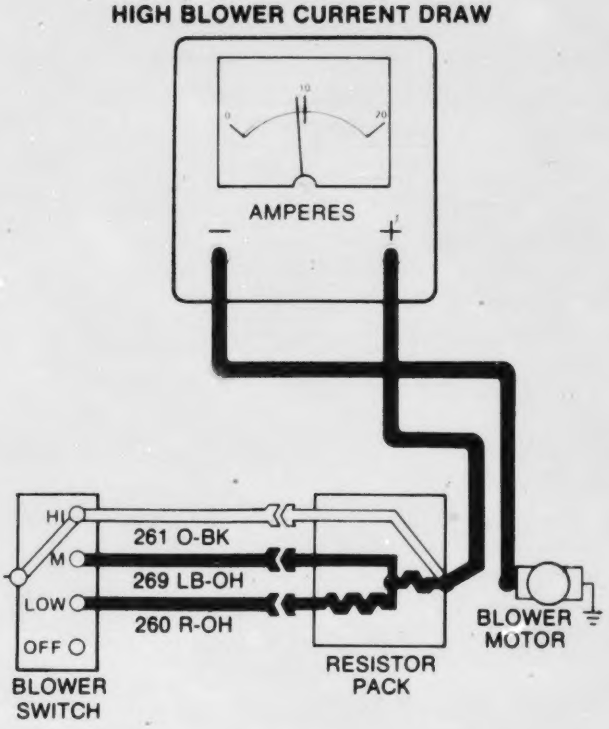
         c. Turn on ignition switch

         d. Observe meter reading

         (NOTE: It should be approximately 8 amperes.)

JOB SHEET #11

FIGURE 1


HIGH BLOWER CURRENT DRAW
0
10
20
AMPERES
−
+
HI
M
LOW
OFF
261 O-BK
269 LB-OH
260 R-OH
BLOWER SWITCH
RESISTOR PACK
BLOWER MOTOR

(NOTE: With the blower motor on high speed, maximum voltage is available through wire 261 0-BK. The meter should read approximately 8 amperes, which is just about average specified current draw for blower motors on high speed.)

JOB SHEET #11

2. Test current draw with speed control (Figure 2)

   a. Connect ammeter in series between resistor pack and blower motor while observing correct polarity

   b. Set blower switch to medium position

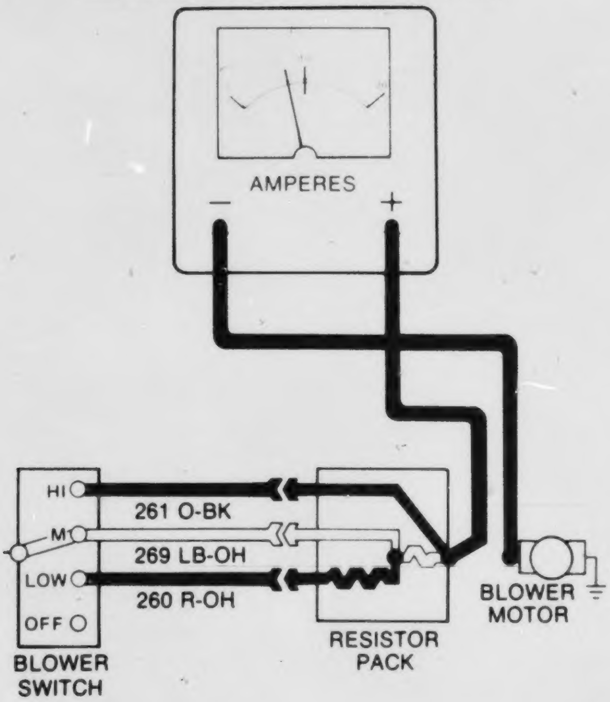
   c. Turn on ignition switch

   d. Observe meter reading

   (NOTE: It should be approximately 6 amperes.)

FIGURE 2

MEDIUM BLOWER CURRENT DRAW


AMPERES
—
+
HI
M
LOW
OFF
261 O-BK
269 LB-OH
260 R-OH
BLOWER SWITCH
RESISTOR PACK
BLOWER MOTOR

(NOTE: With the switch in medium position, current is passed through a resistor to the motor. This reduces the available voltage to the motor. Current draw is about 6 amperes and the motor is running slower. You should conclude that current draw is highest with no resistance and reduces as resistance is added in series.)

JOB SHEET #11

3. Test current draw with additional electrical load (Figure 3)

   (NOTE: Add a second blower motor in parallel and operate both at the same time.)

   a. Connect ammeter in series between resistor pack and the last motor in the circuit, while observing correct polarity

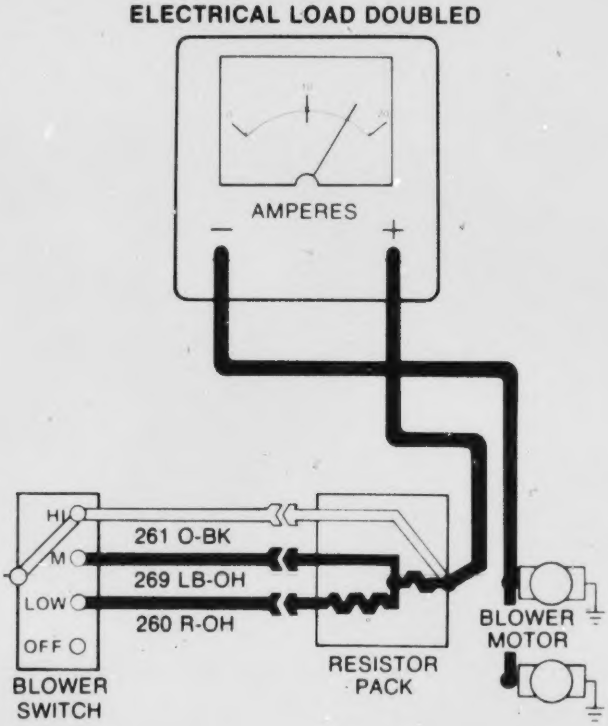
   b. Set blower switch to high speed position

   c. Turn on ignition switch

   d. Observe meter reading

      (NOTE: It should be approximately 16 volts or maximum battery voltage.)

FIGURE 3


ELECTRICAL LOAD DOUBLED
AMPERES
−
+
HI
M
LOW
OFF
261 O-BK
269 LB-OH
260 R-OH
BLOWER SWITCH
RESISTOR PACK
BLOWER MOTOR

(NOTE: The effective resistance of the circuit actually decreases as parallel loads are added. Had the two motors been connected in series, both would run at reduced speed because one would act as a resistor for the other. You should conclude that whenever electrical loads are added in parallel, the current draw increases.)

JOB SHEET #11

4. Test current draw with additional mechanical load on the motor (Figure 4)

   a. Connect ammeter in series between the resistor pack and blower motor while observing correct polarity

   b. Set blower switch to high speed

   c. Connect a mechanical load to the blower motor

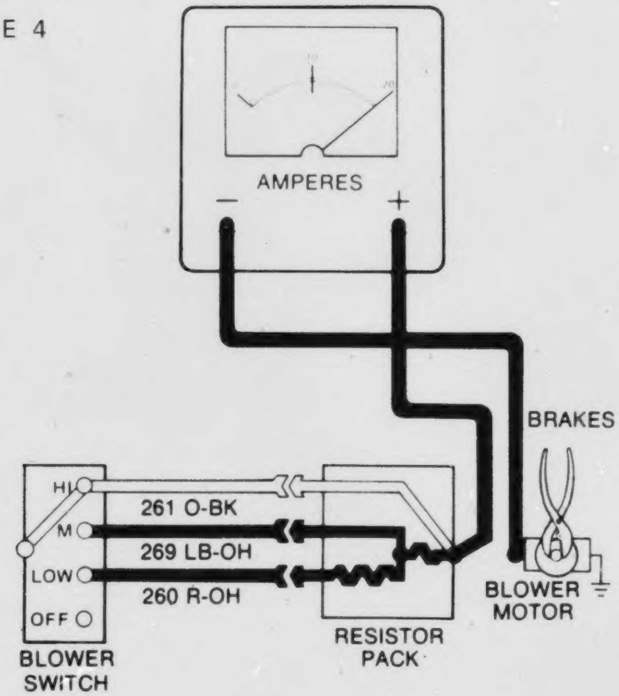
   (NOTE: A screwdriver dragging against the smooth end of the blower cage is a convenient way of loading the motor.)

   d. Turn on ignition switch

   e. Observe meter reading when the motor is stalled by mechanical load

MECHANICAL "BIND" ON MOTOR

FIGURE 4


AMPERES
−
+
BRAKES
HI
M
LOW
OFF
261 O-BK
269 LB-OH
260 R-OH
BLOWER SWITCH
RESISTOR PACK
BLOWER MOTOR

(NOTE: The ammeter may read off the scale because of the additional load. Of course, the higher load will open the fuse or circuit breaker to prevent the motor from burning out. A current draw test is useful to determine if a motor is operating against a mechanical bind.)

CHASSIS WIRING
UNIT VI

TEST

NAME____ SCORE____________ __

1. Match the terms on the right to the correct definitions. (Answers for "a" through "k" are on this page.)

______a. Unit of measurement of the electrical pressure in a circuit; measured with a voltmeter

______b. Unit of measurement of the amount of electrical current passing a given point; measured with an ammeter

______c. Opposition to current flow in a circuit; measured in ohms

______d. Material which carries electrical current from the source to the load and back to the source

______e. Material that prevents electrical current from transferring from one conductor to another

______f. Current has only one path through circuit

______g. Current has two or more paths through which to travel through circuit

______h. Combination of both series and parallel circuits

______i. Conductor (wire) is broken or connections are poor and will not support current flow

______j. Mechanical device used to open and close a circuit

______k. Some kind of screw, post, pin, or socket at the end of a wire or cable

1. Amperage
2. Insulator
3. Conductor
4. Voltage
5. Resistance
6. Series circuit
7. Open circuit
8. Series-parallel circuit
9. Parallel circuit
10. Terminal
11. Switch

______l. Collective term applied to the positive and negative ends of a magnet; direction of current flow in a circuit

______m. Electrical device that produces light

______n. Fine-coiled tungsten wires which are vacuum sealed in a glass chamber

______o. Bulb with only one filament

______p. Bulb with two filaments

______q. Any system of wires which are taped together for electrical distribution throughout the vehicle

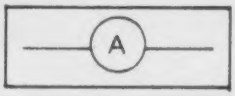
______r. Defect which permits current to take a shorter path instead of following the prescribed path

______s. Continuous path along a conductor through which electrical current can flow from a source, through a load, and back to the source

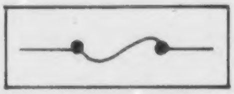
______t. Negative or uninsulated side of a circuit in a vehicle

12. Filament
13. Single filament
14. Wiring harness
15. Double filament
16. Bulb
17. Short or short circuit
18. Polarity
19. Circuit
20. Ground

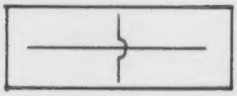
2. Identify common electrical symbols.



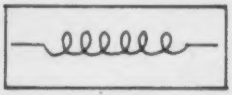
a. ____________



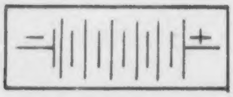
b. ____________



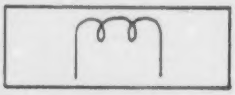
c. ____________



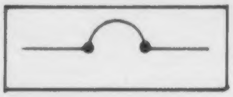
d. ____________



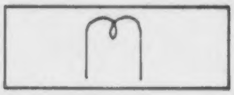
e. ____________



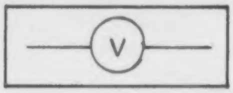
f. ____________



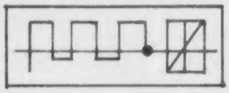
g. ____________



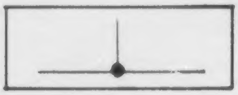
h. ____________



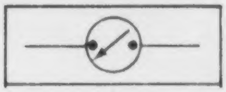
i. ____________



j. ____________

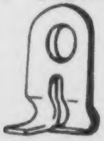


k. ____________

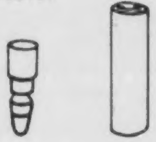


l. ____________

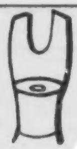
3. Identify the following electrical terminals and connectors.



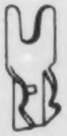
a. ____________________



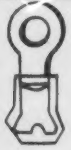
b. ____________________



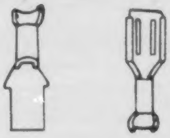
c. ____________________



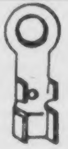
d. ____________________



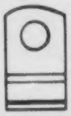
e. ____________________



f. ____________________



g. ____________________



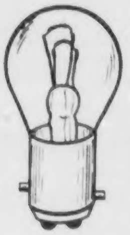
h. ____________________

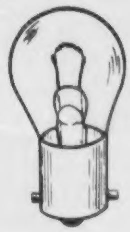
4. Name two types of bulbs used in an automobile.

a. ____

b. ____

5. Label the parts of the sealed beam lamp illustrated below by writing the correct names in the blanks provided.





a. ____________________

b. ____________________

6. Distinguish between hot (H) and ground (G) circuits by placing the appropriate letters in the blanks provided.

   ______a. That part of a circuit from battery positive terminal to the load which usually includes circuit protector, switch, and other control mechanisms

   ______b. That part of the circuit from the load back to the negative terminal of the battery

7. List three facts about voltage drop.

   a. ____

   ____

   b. ____

   ____

   c. ____

   ____

8. List three facts about current draw.

   a. ____

   ____

   b. ____

   ____

   c. ____

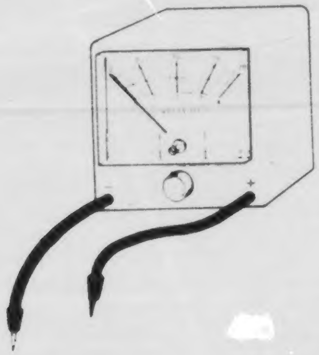
   ____

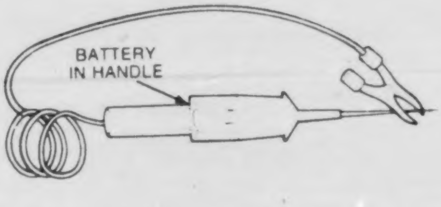
9. Distinguish between single (S) and two-wire circuits (T) by placing the appropriate letters in the blanks.

   ______a. Circuit which uses a wire on the hot side and a wire for the ground side of the circuit

   ______b. Circuit in which a wire is used on the hot side of the circuit and the vehicle chassis is used for the ground side of the circuit

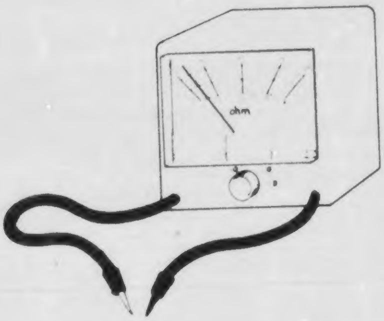
10. Identify the following electrical test instruments.

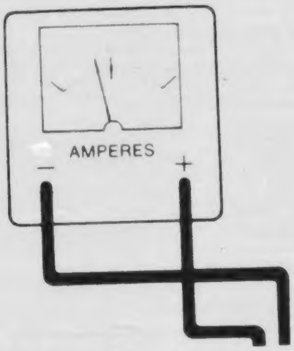



BATTERY
IN HANDLE

a. ____________________

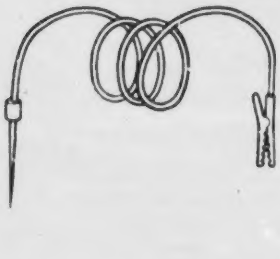
b. ____________________

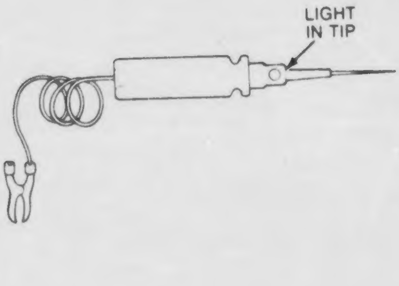




c. ____________________

d. ____________________




LIGHT
IN TIP

e. ____________________

f. ____________________

11. Arrange in order the steps to follow in diagnosing electrical problems.

    ______a. Repair

    ______b. Isolate the problem

    ______c. Determine the problem

    ______d. Test systematically

    ______e. Verify the problem

    ______f. Test the repair

    ______g. Trace the circuit

12. Select from the following list characteristics of a wiring diagram by placing an "X" in the correct blanks.

    ______a. Wiring diagrams are needed only for beginning mechanics

    ______b. Lines represent wires

    ______c. Wires have identification numbers

    ______d. Troubleshooting suggestions are included on the diagram

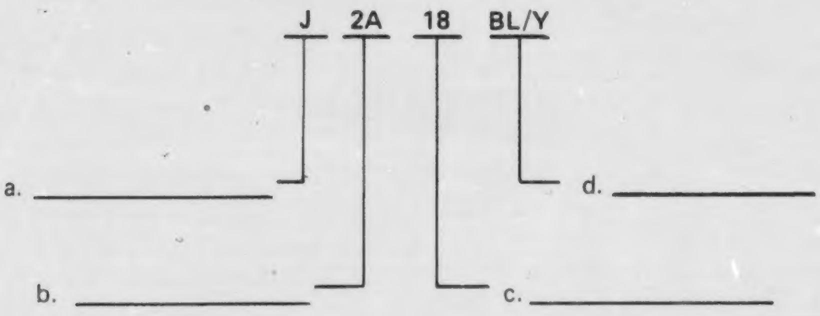
    ______e. Wires are color-coded

    ______f. Components are represented by symbols

    ______g. Wiring diagrams indicate points where test instruments should be connected

    ______h. Symbols indicate locations of circuits or components in the vehicle

13. Label the parts of the following circuit identification code by filling in the blanks.



14. Read a wiring diagram.

15. Troubleshoot an electrical circuit.

16. Demonstrate the ability to:

    a. Install a soldered terminal.

    b. Install a solderless terminal.

    c. Splice a wire (soldered method).

    d. Splice a wire (solderless method).

    e. Remove and replace a bulb.

    f. Align headlights.

    g. Remove and replace a sealed beam.

    h. Remove and replace a headlight switch.

    i. Remove and replace a power window motor.

    j. Test circuit with voltmeter.

    k. Test electrical motor current draw.

    (NOTE: If activities 14-16 have not been accomplished prior to the test, ask the instructor when they should be completed.)

CHASSIS WIRING
UNIT VI

ANSWERS TO TEST

1.
   a. 4
   b. 1
   c. 5
   d. 3
   e. 2
   f. 6
   g. 9
   h. 8
   i. 7
   j. 11
   k. 10
   l. 18
   m. 16
   n. 12
   o. 13
   p. 15
   q. 14
   r. 17
   s. 19
   t. 20

2.
   a. Ammeter
   b. Fuse
   c. Crossover conductor
   d. Coil
   e. 12-volt battery
   f. Double-filament lamp
   g. Circuit breaker
   h. Single-filament lamp
   i. Voltmeter
   j. Voltage limiter
   k. Connected conductor
   l. Gauge (temperature or fuel)

3.
   a. Solder roll terminal
   b. Bullet connector
   c. Solderless spade terminal
   d. Solder spade terminal

e. Solderless ring terminal

f. Blade connector

g. Solder ring terminal

h. Solderless roll terminal

4. a. Single filament

b. Double filament

5. a. Locating lug

b. Electrical terminals

c. Filaments

d. Reflector

e. Aiming lug

f. Lens

g. Number indicating type of filament

6. a. H

b. G

7. Any three of the following:

a. Voltage drop occurs when electricity flows through a resistance

b. Resistance can be the load, a resistor used for motor speed control or lamp brightness, or a poor connection in either hot or ground circuit

c. Voltage drop can be measured directly by connecting the voltmeter across the component with the circuit operating

d. Voltage drop adds up when connected in series with the load

8. Any three of the following:

a. Current draw cannot be read in an open circuit because there is no current flow

b. Current draw is highest with no resistance

c. Current draw reduces as resistance is added in series

d. Current draw increases as loads are added in parallel

e. Current draw test is useful to determine if a motor is operating against a mechanical bind

9. a. T
    b. S
10. a. Voltmeter
    b. Continuity test light, self-powered
    c. Ohmmeter
    d. Ammeter
    e. Jumper wire
    f. Continuity test light
11. a. 6
    b. 3
    c. 1
    d. 4
    e. 5
    f. 7
    g. 2
12. b, c, e, f, h
13. a. Main circuit identification
    b. Part of main circuit
    c. Gauge of wire (18 gauge)
    d. Color of wire (black with pink stripe)
14. Evaluated to satisfaction of instructor
15. Evaluated to satisfaction of instructor
16. Performance skills evaluated to satisfaction of instructor

CLUTCH ASSEMBLY
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to describe the construction and operation of the clutch assembly. The student should demonstrate the ability to remove, inspect, and correctly replace a clutch assembly. This knowledge will be evidenced through demonstration and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with the clutch assembly to the correct definitions.
2. Identify the components of the clutch assembly.
3. Identify the parts of a clutch disc.
4. List types of pressure plates.
5. Discuss clutch operation.
6. List methods used to actuate clutch release.
7. Describe mechanisms that allow a smooth clutch engagement.
8. Select from a list conditions to look for during clutch inspection.
9. Select from a list symptoms that may occur when the clutch housing bore has excessive runout.
10. Match clutch malfunctions to probable causes.
11. Demonstrate the ability to:
    a. Adjust clutch linkage free travel.
    b. Remove clutch assembly.
    c. Inspect clutch assembly.
    d. Check clutch housing alignment.
    e. Replace clutch assembly.

CLUTCH ASSEMBLY
UNIT I

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate the procedures outlined in the job sheets.

   G. Give test.

II. Unit references:

   A. Crouse, William S., and Anglin, Donald L. *Automotive Transmissions and Power Trains.* 5th ed. New York: Gregg Div./McGraw-Hill Book Co., 1976.

   B. Crouse, William H. *Automotive Mechanics.* 7th ed. New York: McGraw-Hill Book Co., 1975.

   C. Ellinger, Herbert E. *Automechanics.* Englewood Cliffs, New Jersey: Prentice-Hall Inc., 1972.

   D. *Ford Service Manual.* Dearborn, Michigan: Ford Motor Co., 1975-76.

   E. *Chevrolet Service Manual.* Detroit: Chevrolet Motor Div./General Motors Corp., 1977.

   F. *Chrysler, Plymouth, Dodge Service Chassis Manual.* Detroit: Chrysler Corp., 1976.

CLUTCH ASSEMBLY
UNIT I

INFORMATION SHEET

I. Terms and definitions (Transparency 1)

   A. Clutch disc--Plate which provides friction between pressure plate and flywheel

   B. Pressure plate--Housing, spring, and plate assembly which provides pressure to clamp clutch disc between pressure plate and flywheel

   C. Release bearing--Bearing which provides a method of releasing spring pressure of the pressure plate

   D. Release fork--**Y**-shaped lever inside clutch housing used to engage and disengage clutch

   E. Flywheel--Heavy metal disc which has a friction surface for the clutch plate and supports all of the clutch components

   F. Free travel--Amount of clutch pedal movement before release bearing contacts pressure plate fingers

   G. Pilot bearing--Bearing located in the flywheel flange of the crankshaft which allows for correct support and alignment of transmission input shaft

   H. Clutch disc spin time--Time it takes for the clutch disc to stop spinning after clutch release

II. Components of a clutch assembly (Transparency 1)

   A. Release bearing

   B. Release fork

   C. Pressure plate

   D. Clutch disc

   E. Flywheel

III. Parts of a clutch disc (Transparency 2)

   A. Friction ring

   B. Hub flange

   C. Stop pin

   D. Cushion springs

INFORMATION SHEET

   E. Torsional coil spring

   F. Facings

   G. Drive washer

IV. Types of pressure plates (Transparency 3)

   A. Diaphragm

      (NOTE: A thin, dished steel plate is used for a spring effect.)

   B. Coil spring

      (NOTE: Pressure is provided by a group of coil springs.)

   C. Centrifugal

      (NOTE: Pressure is provided by a combination of coil springs and centrifugal weights.)

V. Clutch operation (Transparency 4)

   A. Engaged--Spring pressure clamps clutch disc between pressure plate and flywheel face

   B. Disengaged--Release bearing and linkage are used to release spring pressure

VI. Methods used to actuate clutch release

   A. Links, levers, and rods connected to transfer motion from clutch pedal to release fork

   B. Hydraulic system using a master cylinder and slave cylinder to transfer motion from clutch pedal to release fork

VII. Mechanisms that allow smooth clutch engagement (Transparency 2)

   A. Cushioning device--Thin, waved cushion spring between clutch disc facings

   B. Dampening device--Series of heavy coil springs placed in the clutch disc hub to absorb shock

VIII. Conditions to look for during clutch inspection (Transparencies 5 and 6)

   A. Normal finger wear

   B. Excessive finger wear

   C. Slight chatter marks

INFORMATION SHEET

- D. Excessive heat discoloration
- E. Excessive warpage
- F. Heat cracks
- G. Wear pattern from warped pressure plate or flywheel
- H. Worn clutch disc
- I. Loose or worn clutch disc hub
- J. Worn clutch shaft spline
- K. Worn pilot bearing
- L. Weak pressure plate spring tension
- M. Release fork pivot and finger wear
- N. Notched or rough release bearing support

IX. Symptoms that may occur when a clutch housing bore has excessive runout

- A. Excessive transmission gear wear or noise
- B. Transmission jumping out of gear
- C. Drive line vibration
- D. Clutch pedal vibration
- E. Scrubby pedal feel
- F. Pilot bearing noise
- G. Excessive clutch spin time

X. Clutch malfunctions and probable causes

- A. Slip
  - 1. Pressure plate spring tension weak
  - 2. Excessively worn clutch disc
  - 3. Oil contamination
  - 4. Improperly adjusted clutch linkage

INFORMATION SHEET

B. Drag

1. Pressure plate not releasing due to improper linkage adjustment
2. Broken pivots in pressure plate

C. Grab

1. Oil contamination on clutch assembly
2. Broken motor mounts
3. Glazed clutch surface from being overheated

D. Chatter

1. Oil contamination
2. Clutch disc glazed from overheating
3. Warped pressure plate or flywheel
4. Weak pressure plate spring

E. Freezing--Water-contaminated clutch disc rusted to flywheel and pressure plate

F. Binding

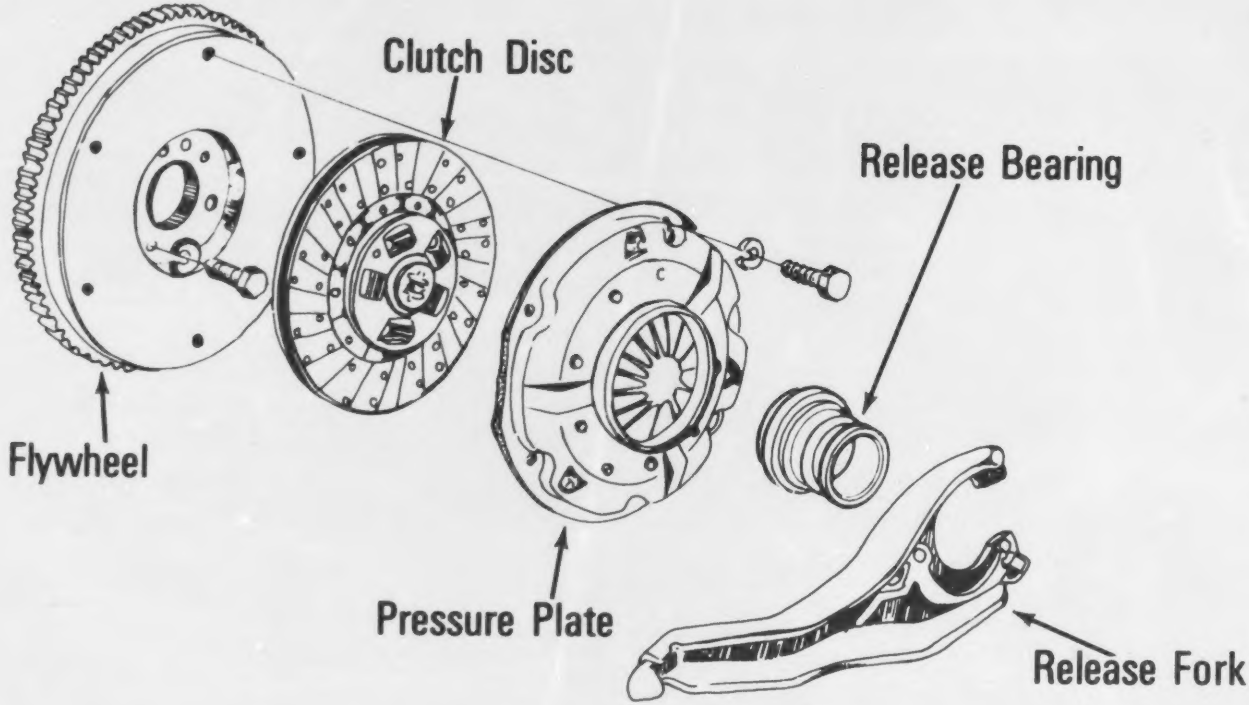
1. Worn or misaligned linkage
2. Release bearing dragging on support

G. Bearing noise

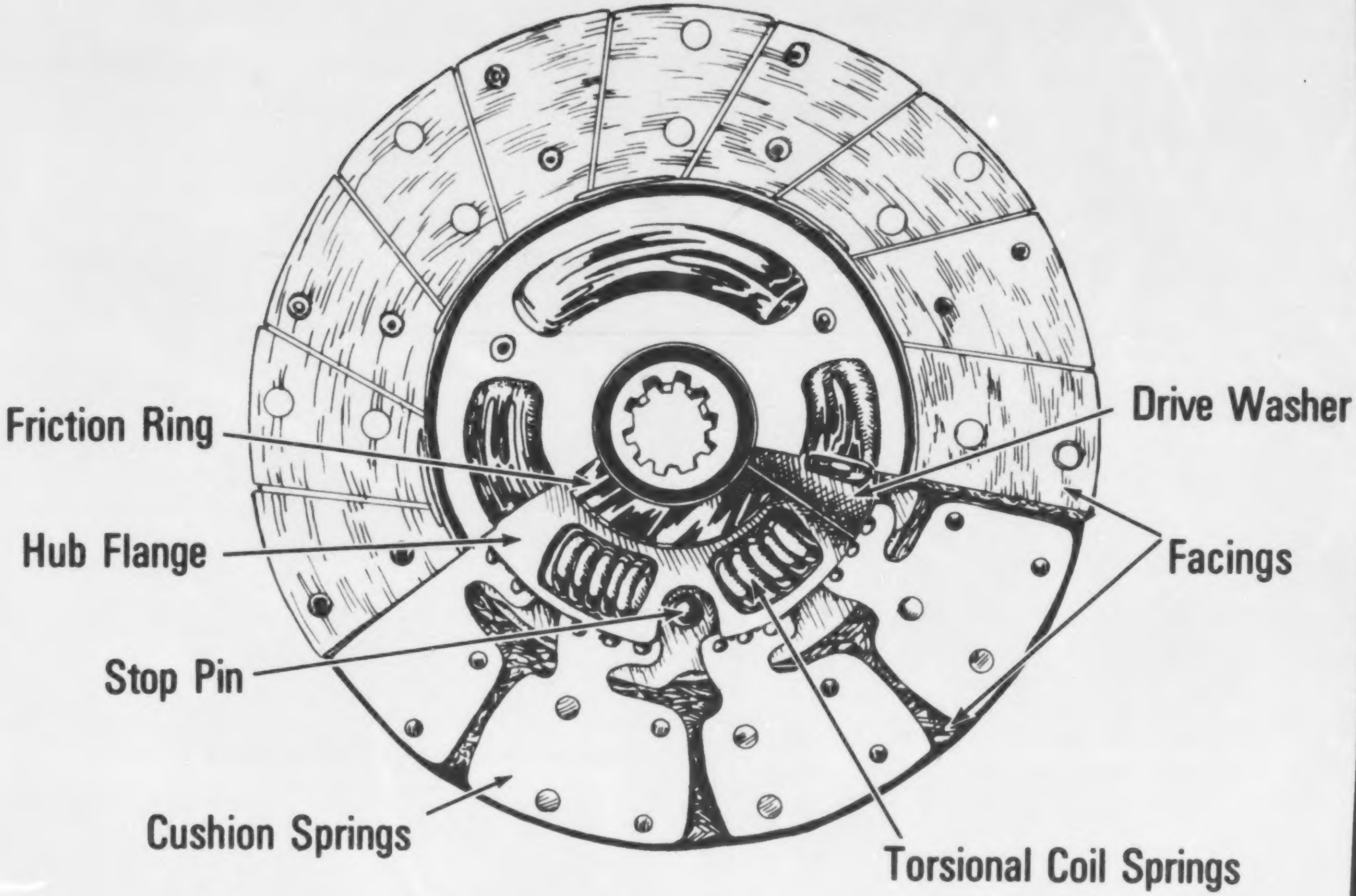
1. Worn or dry pilot or release bearing when clutch is disengaged
2. Pitted clutch shaft bearing when the clutch is engaged with transmission in neutral

H. Pulsating pedal--Uneven pressure plate finger height

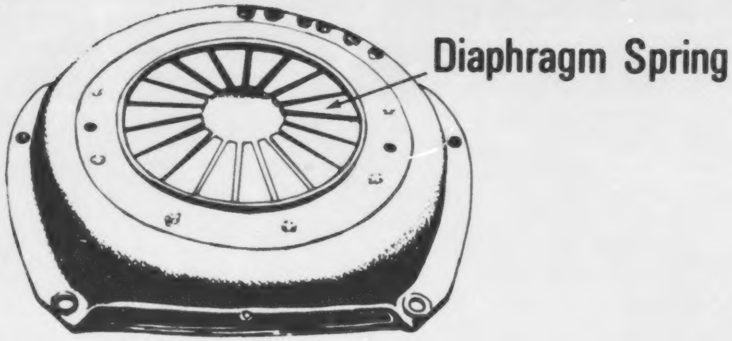
Clutch Assembly


Clutch Disc
Release Bearing
Flywheel
Pressure Plate
Release Fork

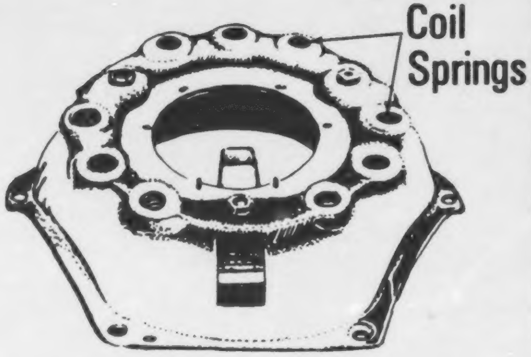
Parts Of A Clutch Disc


Friction Ring
Hub Flange
Stop Pin
Cushion Springs
Drive Washer
Facings
Torsional Coil Springs

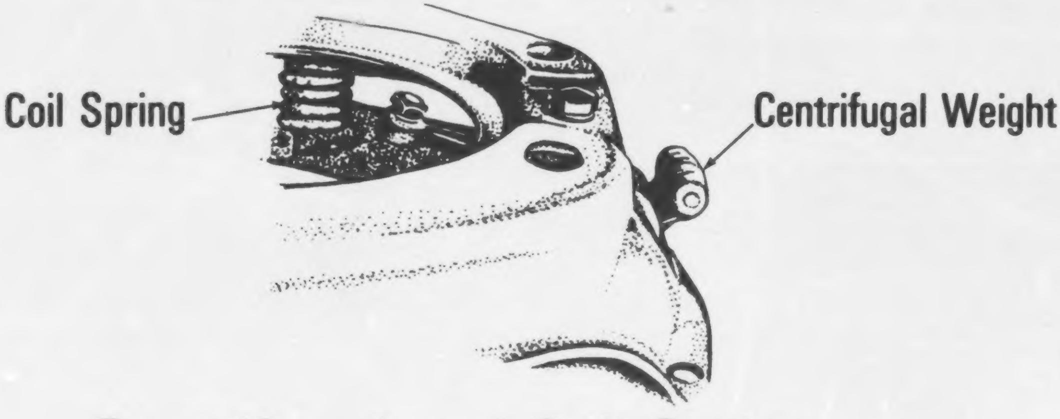
Types Of Pressure Plates


Diaphragm Spring

Diaphragm or Belleville Spring

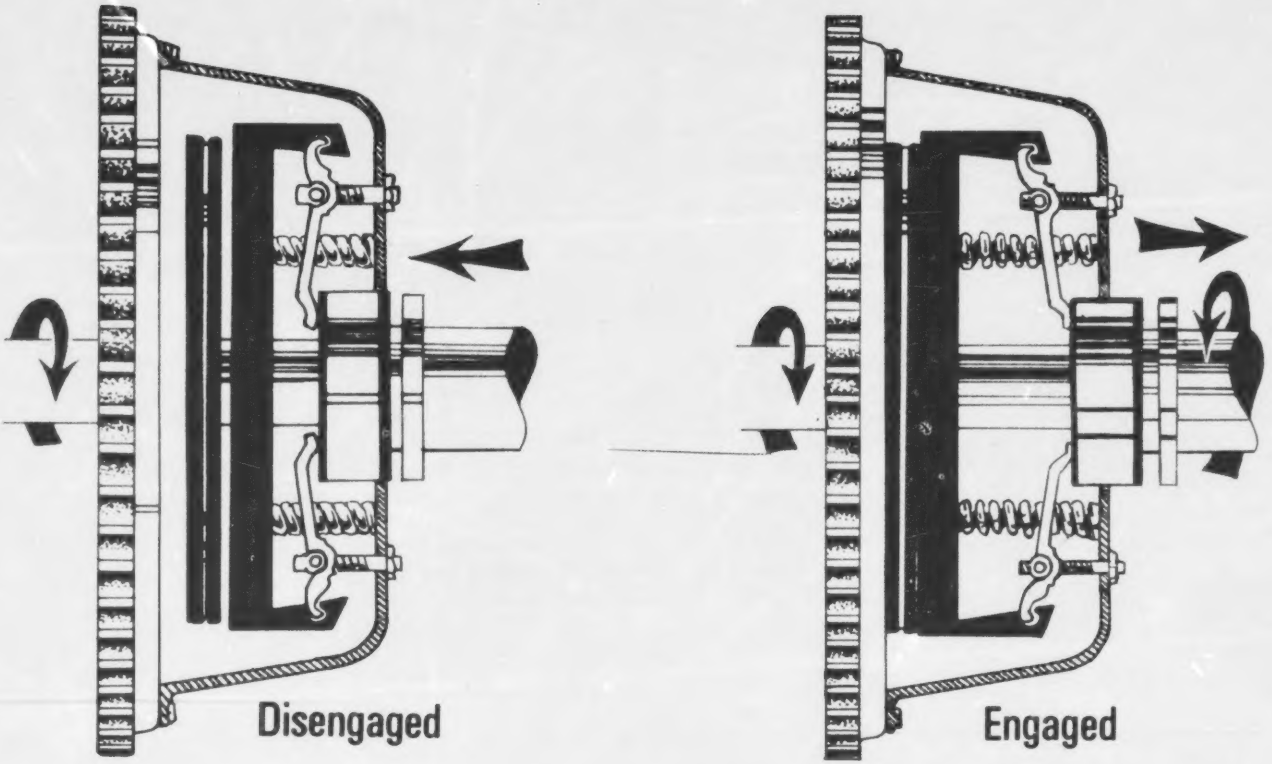

Coil
Springs

Coil Spring


Coil Spring
Centrifugal Weight

Centrifugal and Coil Spring

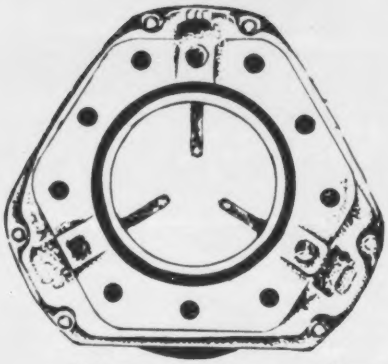
Clutch Operation

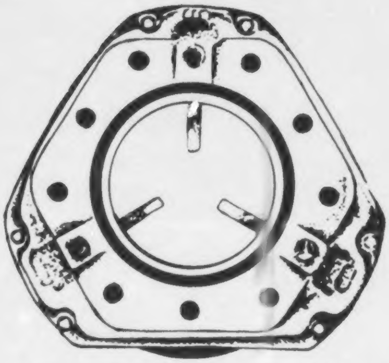


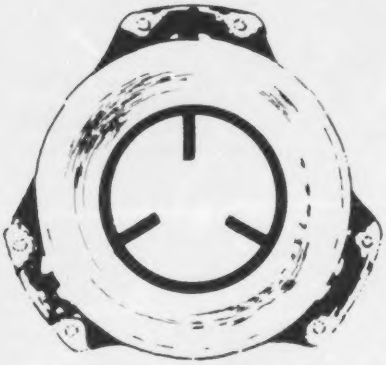
Disengaged

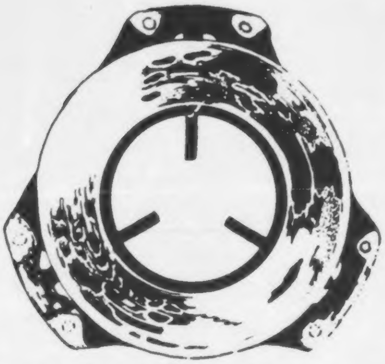
Engaged

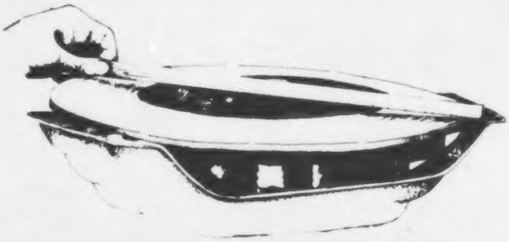
Clutch Inspection

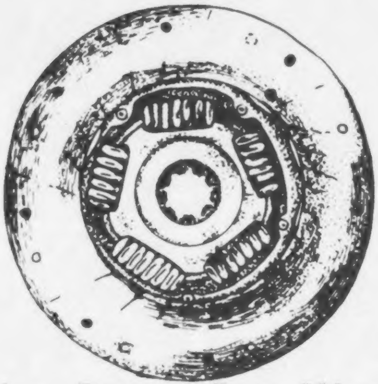

Normal Finger Wear


Excessive Finger Wear


Slight Chatter Marks

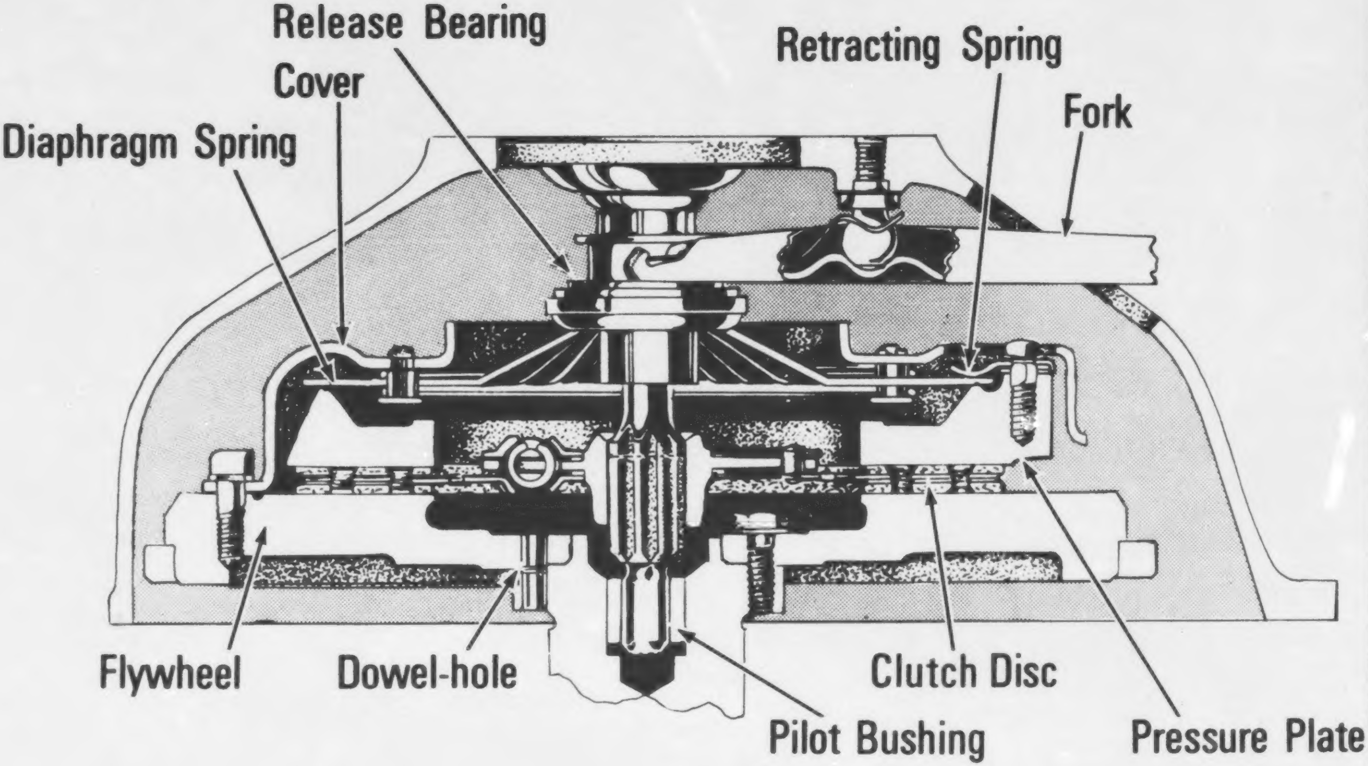

Excessive Heat Discoloration


Excessive Warpage


Wear Pattern From Warped Pressure Plate Or Flywheel

Clutch Inspection

(Continued)


Release Bearing
Retracting Spring
Cover
Fork
Diaphragm Spring
Flywheel
Dowel-hole
Clutch Disc
Pilot Bushing
Pressure Plate

CLUTCH ASSEMBLY
UNIT I

JOB SHEET #1--ADJUST CLUTCH LINKAGE FREE TRAVEL

I. Tools and equipment

   A. Basic hand tool set

   B. Floor jack

   C. Jack stands, 4

   D. Drop light

   E. Creeper

   F. Safety glasses

II. Procedure

   A. Make sure clutch pedal returns firmly against pedal bumper when released

   B. Locate adjustment on clutch linkage

   (NOTE: On some cars the clutch adjustment is made under the hood. If adjustment is made under the car, support vehicle on jack stands.)

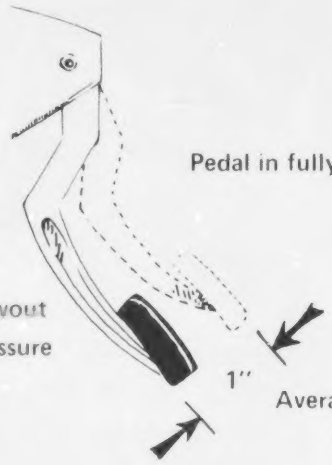
   C. Check clutch linkage for binding

   D. Adjust clutch linkage

   E. Adjust linkage until desired free travel is obtained (Figure 1)

   (NOTE: Adjust linkage to manufacturer's specifications. Usually, about one inch of clutch pedal free travel is desired.)

FIGURE 1


Pedal in fully extended position
Point at which the throwout bearing contacts the pressure plate release fingers
1"
Average Free Travel 25.4 mm

ADJUST CLUTCH FREE TRAVEL

CLUTCH ASSEMBLY
UNIT I

JOB SHEET #2--REMOVE CLUTCH ASSEMBLY

I. Tools and equipment

- A. Floor jack
- B. Jack stands, 4
- C. Basic hand tool set
- D. Battery cable pliers
- E. Extra propeller shaft slip joint yoke
- F. Transmission jack
- G. Engine support tool
- H. Suitable wood blocks, 2" x 4" x 6" long (50 mm x 100 mm x 150 mm)
- I. Drop light
- J. Creeper
- K. Shop towels
- L. Safety glasses

II. Procedure

- A. Disconnect ground battery cable
- B. Support vehicle on jack stands
- C. Mark propeller shaft for reinstallation
- D. Remove propeller shaft
- E. Place extra slip joint yoke on transmission output shaft
- F. Secure rollers on propeller shaft with tape
- G. Disconnect transmission shift linkage
- H. Disconnect speedometer cable

  (NOTE: It may be necessary to support the rear of the engine before transmission removal if the transmission has a rear engine mount attached.)

- I. Disconnect rear mount

JOB SHEET #2

J. Raise transmission just enough to clear crossmember

K. Remove crossmember as necessary

(CAUTION: As the transmission is lowered, the distributor cap, radiator hoses, or fan blades could be damaged by interfering with stationary parts.)

L. Lower transmission and support the rear of the engine

M. Remove dust cover from clutch housing if so equipped

N. Remove transmission attaching bolts

(CAUTION: Use a transmission jack of some type for removal of transmission.)

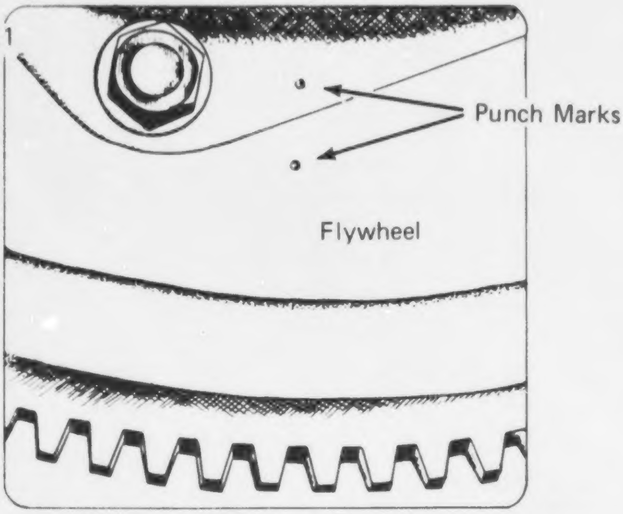
O. Remove transmission

P. Remove clutch release bearing

Q. Remove the clutch housing if there is no dust cover

R. Mark flywheel and pressure plate with a center punch while clutch assembly is exposed (Figure 1)

FIGURE 1



Marking Clutch and Flywheel

S. Remove pressure plate attaching bolts

(CAUTION: A bar should be placed through the clutch disc and pressure plate to prevent them from falling as the attaching bolts are removed.)

T. Remove clutch and pressure plate

CLUTCH ASSEMBLY
UNIT I

JOB SHEET #3--INSPECT CLUTCH ASSEMBLY

I. Tools and equipment

   A. Solvent container

   B. Solvent

   C. Brush

   D. Drop light

   E. Shop towels

   F. Safety glasses

II. Procedure

   A. Wash pressure plate and clutch housing in suitable solvent

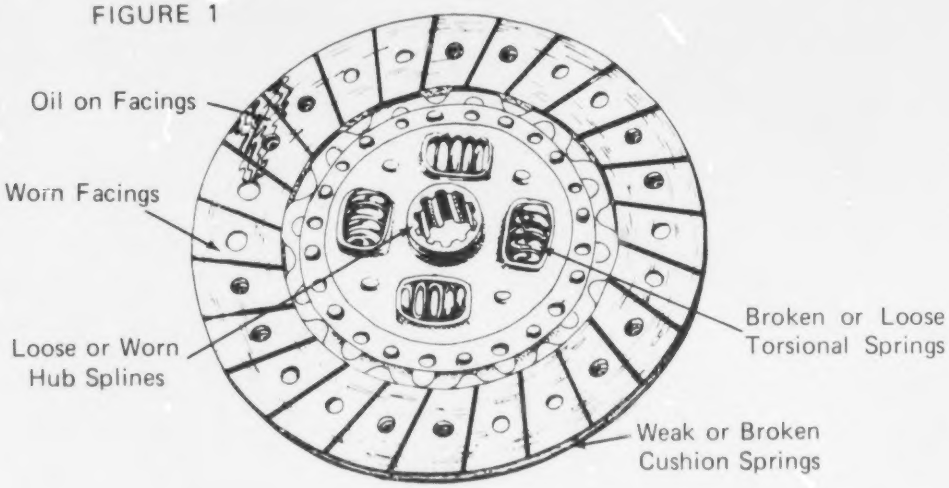
   (CAUTION: Do not wash release bearing in solvent because it would wash out the lubricant and ruin the bearing. Do not wash clutch disc in solvent because the facings would be damaged.)

   B. Inspect the flywheel for scoring and roughness

   C. Inspect the pressure plate for scoring, roughness, and broken springs

   D. Inspect the clutch disc for wear or damage (Figure 1)

FIGURE 1


Oil on Facings
Worn Facings
Loose or Worn Hub Splines
Broken or Loose Torsional Springs
Weak or Broken Cushion Springs

   E. Inspect clutch release bearing for excessive wear on contact face; check for roughness of balls and races

CLUTCH ASSEMBLY
UNIT I

JOB SHEET #4--CHECK CLUTCH HOUSING ALIGNMENT

I. Tools and equipment

   A. Basic hand tool set

   B. Dial indicator set

   C. Safety glasses

   D. Clean shop towels

   E. Torque wrench

II. Procedure

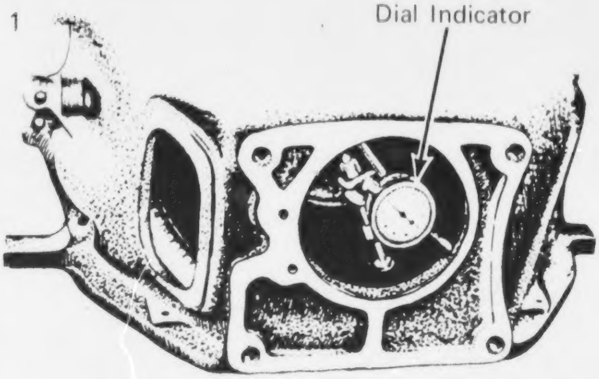
(NOTE: This procedure is accomplished with the transmission and clutch assembly removed. The clutch housing bore and transmission mating surface should be clean.)

   A. Check bore runout

      1. Replace one flywheel-to-crankshaft bolt with a bolt about 3" (76 mm) long

      2. Mount a dial indicator on this bolt (Figure 1)

FIGURE 1



Measuring Housing Bore Runout

(NOTE: The dial indicator contact should set squarely on the bore wall.)

      3. Adjust the dial to "O"

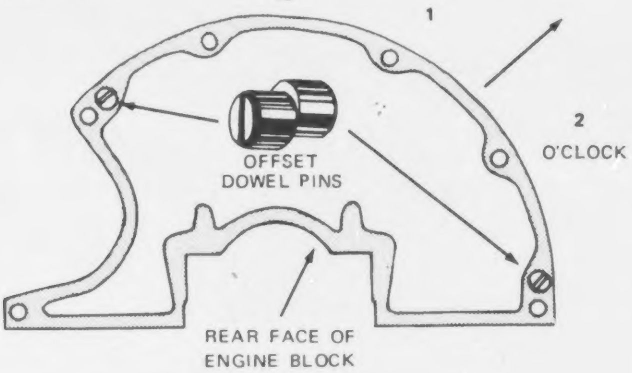
JOB SHEET #4

4. Rotate engine clockwise with a socket wrench on vibration damper bolt at front of crankshaft

5. Record dial indicator needle deflection

(NOTE: Bore out-of-round must not exceed 0.008" [0.48 mm] total indicator reading. Excessive bore runout can be corrected by installing correct size of offset dowel pins. See Figure 2.)

FIGURE 2

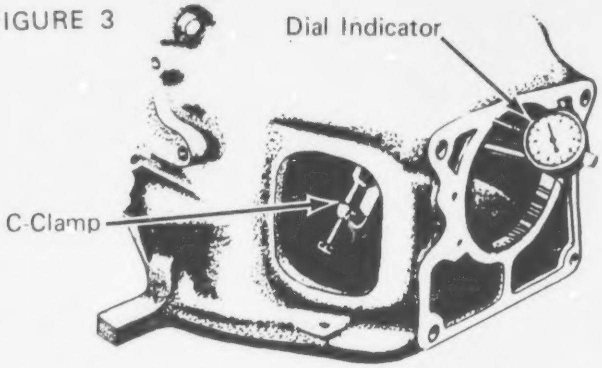

12
1
2
O'CLOCK
OFFSET
DOWEL PINS
REAR FACE OF
ENGINE BLOCK

Offset Dowel Diagram

B. Check face squareness

1. Position dial indicator so the contact will ride squarely on the transmission mating surface of the clutch housing (Figure 3)

FIGURE 3


Dial Indicator
C-Clamp

Measuring Housing Face Squareness

JOB SHEET #4

2. Adjust the dial to "O"

3. Rotate the engine clockwise with a socket wrench on vibration damper bolt at front of crankshaft

4. Record dial indicator reading

   (NOTE: If total indicator reading is greater than 0.006" [0.46 mm], the housing must be squared by placing correct thickness of shim stock between clutch housing and engine block at the point where the indicator arm extended farthest.)

CLUTCH ASSEMBLY
UNIT I

JOB SHEET #5--REPLACE CLUTCH ASSEMBLY

I. Tools and equipment

   A. Basic hand tool set

   B. Jack stands, 4

   C. Floor jack

   D. Engine support stand

   E. Clutch disc alignment tool

   (NOTE: A clutch input shaft identical to that of the transmission may be used for clutch alignment.)

   F. Safety glasses

   G. Transmission jack

   H. Extra propeller shaft slip joint yoke

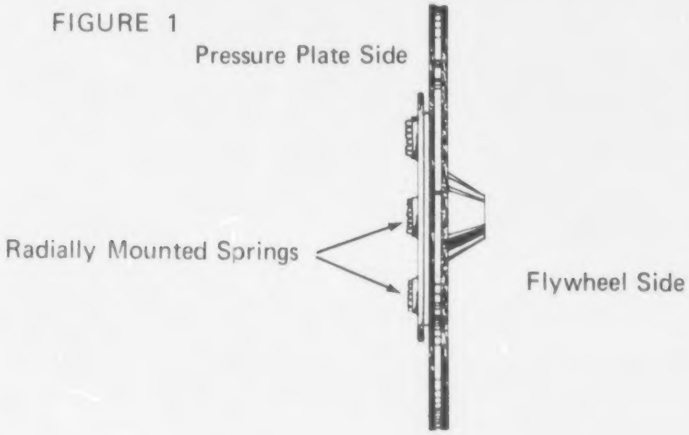
II. Procedure

   A. Clean flywheel friction surface

   B. Apply small amount of wheel bearing grease to pilot bearing

   C. Place the clutch disc in the mounting position with the radially mounted springs away from the flywheel (Figure 1)

FIGURE 1

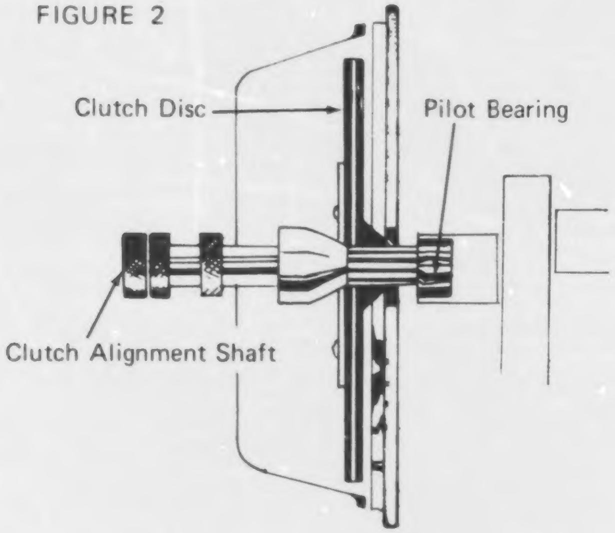


   D. Position pressure plate according to balance marks

JOB SHEET #5

E. Install clutch alignment shaft through pressure plate and clutch disc and extending into the pilot bearing (Figure 2)

FIGURE 2

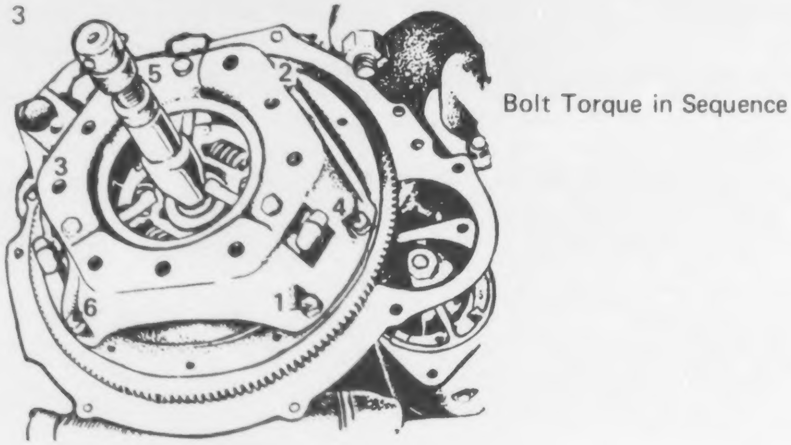

Clutch Disc
Pilot Bearing
Clutch Alignment Shaft

F. Start pressure plate attaching bolts and lock washers

(NOTE: Make sure bolts used for the attachment of the pressure plate are the correct type, usually #5 shouldered bolts.)

G. Tighten bolts in a sequence to avoid distortion of pressure plate (Figure 3)

FIGURE 3


5
2
3
4
6
1
Bolt Torque in Sequence

H. Torque bolts to manufacturer's specifications

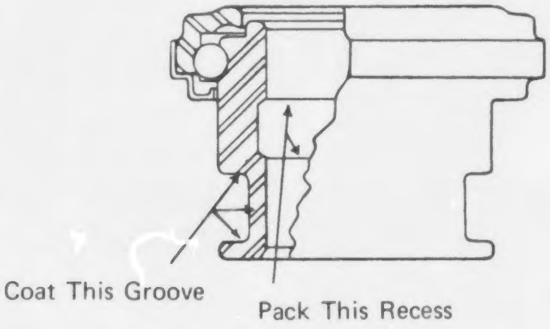
I. Remove clutch alignment shaft

JOB SHEET #5

J. Install clutch housing and starter if applicable

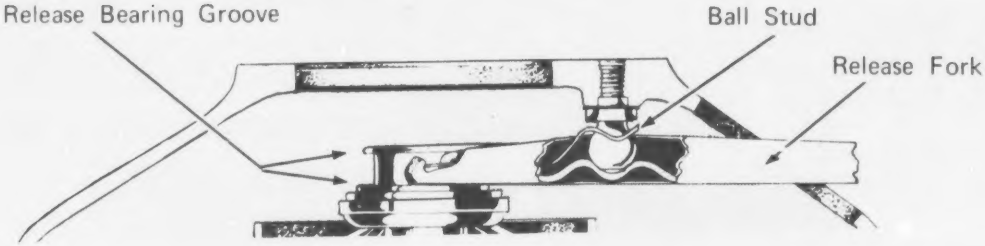
K. Lubricate release bearing sleeve (Figure 4)

FIGURE 4


Coat This Groove
Pack This Recess

L. Make sure release fork is in place (Figure 5)

FIGURE 5


Release Bearing Groove
Ball Stud
Release Fork

JOB SHEET #5

M. Install release bearing

N. Connect clutch linkage

O. Install transmission

(NOTE: Use a transmission jack and guide pins to avoid clutch disc damage during transmission installation.)

(CAUTION: Do not allow transmission weight to hang on clutch disc.)

P. Attach shifting linkage

Q. Install speedometer cable

R. Install rear mount and crossmember if applicable

S. Install propeller shaft while aligning marks

T. Check free travel on clutch pedal; adjust if necessary

(NOTE: Refer to Job Sheet #1 if necessary.)

U. Connect battery ground cable

V. Remove jack stands and lower car to floor

CLUTCH ASSEMBLY
UNIT I

TEST

NAME ______________________________ SCORE ________________

1. Match the terms on the right to the correct definitions.

_____a. Heavy metal disc which has a friction surface for the clutch plate and supports all of the clutch components

_____b. Y-shaped lever inside clutch housing used to engage and disengage clutch

_____c. Plate which provides friction between pressure plate and flywheel

_____d. Time it takes for the clutch disc to stop spinning after clutch release

_____e. Amount of clutch pedal movement before release bearing contacts pressure plate fingers

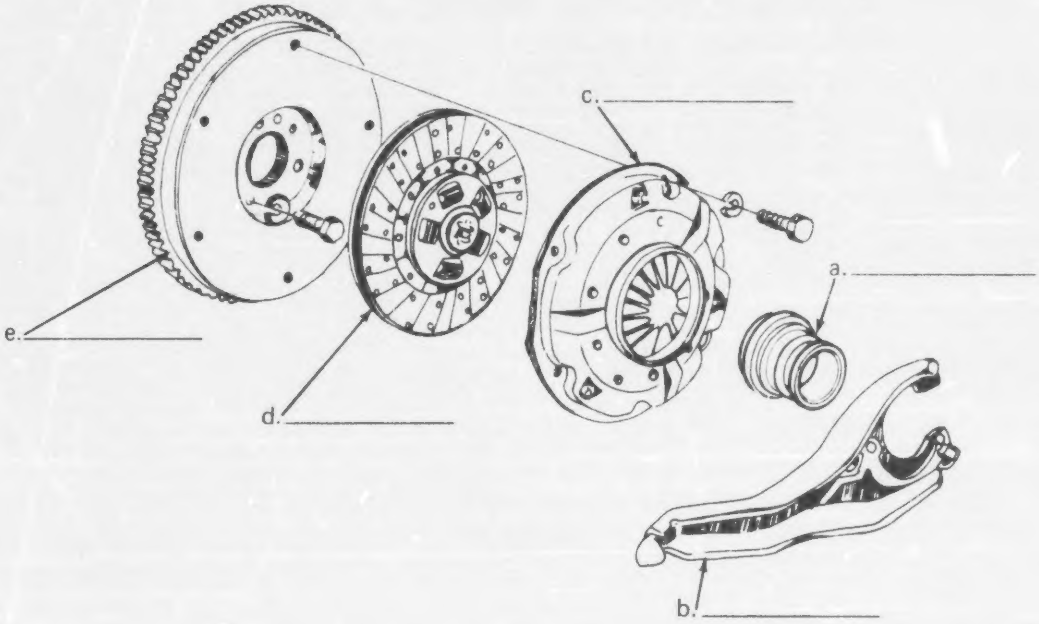
_____f. Bearing located in the flywheel flange of the crankshaft which allows for correct support and alignment of transmission input shaft

_____g. Bearing which provides a method of releasing spring pressure of the pressure plate

_____h. Housing, spring, and plate assembly which provides pressure to clamp clutch disc between pressure plate and flywheel

1. Clutch disc
2. Pressure plate
3. Release bearing
4. Release fork
5. Flywheel
6. Free travel
7. Pilot bearing
8. Clutch disc spin time

2. Identify the components of the clutch assembly below by writing the correct names in the blanks provided.



3. Identify the parts of the clutch disc below by placing the number of the part in the blank next to the correct name.

______a. Cushion spring

______b. Stop pin

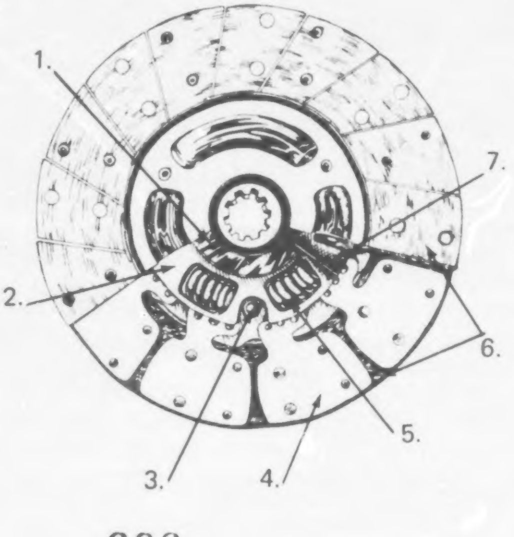
______c. Hub flange

______d. Drive washer

______e. Facings

______f. Torsional coil spring

______g. Friction ring



4. List the three types of pressure plates.

a. ______________________________

b. ______________________________

c. ______________________________

5. Discuss clutch operation in the following positions.

a. Engaged-- ______________________________

____

b. Disengaged-- ______________________________

____

6. List two methods used to actuate clutch release.

a. ______________________________

____

b. ______________________________

____

7. Describe two mechanisms that allow a smooth clutch engagement.

a. ______________________________

____

b. ______________________________

____

8. Select from the list conditions to look for during clutch inspection by placing an "X" in the correct blanks.

______a. Normal finger wear

______b. Excessive finger wear

______c. Broken engine motor mounts

______d. Slight chatter marks

______e. Incorrect gear selector adjustment

______f. Excessive heat discoloration

______g. Drive line vibration

______h. Incorrect clutch linkage adjustment

9. Select from the list symptoms that may occur when a clutch housing bore has excessive runout by placing an "X" in the correct blanks.

______a. Transmission jumping out of gear

______b. Rough engine idle

______c. Drive line vibration

______d. Pilot bearing noise

______e. Excessive clutch spin time

______f. Broken motor mounts

______g. Excessive transmission gear wear or noise

______h. Starter gear breakage

10. Match the clutch malfunctions on the right to the probable causes.

______a. Pressure plate spring tension weak; excessively worn clutch disc; oil contamination; improperly adjusted clutch linkage

______b. Pressure plate not releasing due to improper linkage adjustment; broken pivots in pressure plate

______c. Oil contamination on clutch assembly; broken motor mounts; glazed clutch surface from being overheated

______d. Oil contamination; clutch disc glazed from overheating; warped pressure plate or flywheel; weak pressure plate spring

______e. Water-contaminated clutch disc rusted to flywheel and pressure plate

______f. Worn or misaligned linkage; release bearing dragging on support

______g. Worn or dry pilot or release bearing when clutch is disengaged; pitted clutch shaft bearing when the clutch is engaged with transmission in neutral

______h. Uneven pressure plate finger height

1. Chatter
2. Pulsating pedal
3. Freezing
4. Slip
5. Grab
6. Bearing noise
7. Drag
8. Binding

11. Demonstrate the ability to:

    a. Adjust clutch linkage free travel.

    b. Remove clutch assembly.

    c. Inspect clutch assembly.

    d. Check clutch housing alignment.

    e. Replace clutch assembly.

    (NOTE: If the above activities have not been accomplished prior to the test, ask the instructor when they should be completed.)

CLUTCH ASSEMBLY
UNIT I

ANSWERS TO TEST

1. a. 5
   b. 4
   c. 1
   d. 8
   e. 6
   f. 7
   g. 3
   h. 2
2. a. Release bearing
   b. Release fork
   c. Pressure plate
   d. Clutch disc
   e. Flywheel
3. a. 4
   b. 3
   c. 2
   d. 7
   e. 6
   f. 5
   g. 1
4. a. Diaphragm
   b. Coil spring
   c. Centrifugal

5. Discussion should include:

   a. Engaged--Spring pressure clamps clutch disc between pressure plate and flywheel face

   b. Disengaged--Release bearing and linkage are used to release spring pressure

6. a. Links, levers, and rods connected to transfer motion from clutch pedal to release fork

   b. Hydraulic system using a master cylinder and slave cylinder to transfer motion from clutch pedal to release fork

7. Description should include:

   a. Cushioning device--Thin, waved cushion spring between clutch disc facings

   b. Dampening device--Series of heavy coil springs placed in the clutch disc hub to absorb shock

8. a, b, d, f

9. a, c, d, e, g

10. a. 4

    b. 7

    c. 5

    d. 1

    e. 3

    f. 8

    g. 6

    h. 2

11. Performance skills evaluated to the satisfaction of the instructor

STANDARD TRANSMISSION
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify major parts of a transmission, synchronizer, and electrically operated overdrive system and select correct gear positions when given drawings of a transmission. The student should be able to remove, disassemble, reassemble, and replace a three-speed transmission. This knowledge will be evidenced through demonstration and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. State the purpose of a transmission.
2. Match terms associated with a standard transmission to the correct definitions.
3. Identify the major parts of a transmission.
4. Identify the parts of a synchronizer.
5. List the types of gear teeth commonly used in a standard transmission.
6. Discuss the operation of a three-speed synchromesh transmission.
7. Select the correct gear when given a drawing of a three-speed transmission.
8. List the basic types of overdrives.
9. Identify the components of an electrically operated overdrive.
10. Discuss the operation of an electrically operated overdrive.
11. Demonstrate the ability to:
    a. Remove and replace a standard transmission.
    b. Disassemble, inspect, and reassemble a three-speed transmission.

STANDARD TRANSMISSION
UNIT II

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss procedures outlined on the job sheets.

   G. Give test.

II. Unit references:

   A. Crouse, William H., and Anglin, Donald L. *Automotive Transmissions and Power Trains.* 5th ed. New York: Gregg Div./McGraw-Hill Book Co., 1976.

   B. Crouse, William H. *Automotive Mechanics.* 7th ed. New York: McGraw-Hill Book Co., 1975.

   C. *Ford Service Manual.* Dearborn, Michigan: Ford Motor Co., 1975-76.

   D. *Chrysler, Plymouth, Dodge Chassis Manual*. Detroit: Chrysler Corp., 1976.

   E. *Chevrolet Service Manual.* Detroit: Chevrolet Motor Div./General Motors Corp., 1977.

STANDARD TRANSMISSION
UNIT II

INFORMATION SHEET

I. Purpose of transmission--To provide a method of varying the gear ratio between the engine and rear wheels and to provide a reverse

II. Terms and definitions

   A. Torque--Turning or twisting effort

   B. Constant mesh--Gears that are always in mesh with each other

   C. Synchronizer--Device in the transmission that brings two gears being shifted together to rotate at the same speed

   D. Synchromesh transmission--Transmission using synchronizers that prevent grinding of gear teeth while shifting gears

   E. Gear ratio--Relationship between the number of turns made by a driving gear to complete one full turn of the driven gear

   F. Idler gear--Gear in the transmission used to change direction of rotation of the output shaft

   G. Cluster gear--Group of gears made on a common casting; used in a standard transmission to connect the main drive gear to the first, second, and reverse idler gears

   H. Counter gear--Gear that rotates backward

   (NOTE: The counter gear is the cluster gear in a standard transmission.)

III. Parts of a transmission (Transparency 1)

   A. Input shaft (clutch shaft)

   B. Input shaft bearing retainer

   C. Input shaft gear (main drive gear)

   D. Second and third gear synchronizer assembly

   E. Second speed gear

   F. First speed gear

   G. First and reverse synchronizer assembly

   H. Reverse gear

   I. Output shaft (main shaft)

INFORMATION SHEET

- J. Extension housing
- K. Reverse idler gear shaft
- L. Reverse idler gear
- M. Counter or cluster gear
- N. Transmission case
- O. Counter shaft

IV. Parts of a synchronizer (Transparency 2)

- A. Synchronizer rings
- B. Inserts
- C. Hub
- D. Sleeve
- E. Insert springs

V. Types of gear teeth (Transparency 3)

- A. Spur gear
- B. Helical gear

VI. Three-speed synchromesh transmission operation

- A. Neutral--Input shaft drives the cluster gear which in turn drives the constant mesh second and reverse idler gear; no power is transmitted (Transparency 4)
- B. First gear--First and reverse synchronizer sleeve is moved to engage first gear; power is transmitted from the input shaft to cluster gear, to first gear, and on to output shaft (Transparency 5)
- C. Second gear--Second and third gear synchronizer sleeve is moved to engage second gear; power is transmitted from the input shaft to cluster gear, to second gear, and on to output shaft (Transparency 6)
- D. Third gear--Second and third gear synchronizer sleeve is moved to engage third gear; power is transmitted from the input shaft to the output shaft (Transparency 7)

INFORMATION SHEET

E. Reverse gear--First and reverse synchronizer sleeve is moved to engage reverse idler gear; power is transmitted from the input shaft to the cluster gear; cluster gear drives the reverse idler gear; reverse idler gear drives the reverse gear and output shaft in a direction opposite engine rotation (Transparency 8)

VII. Gear operation of a three-speed transmission (Transparencies 4 through 8)

A. Neutral

B. First gear

C. Second gear

D. Third gear

E. Reverse gear

VIII. Basic types of overdrives

A. Manual fourth gear

(NOTE: This type of overdrive is the same as a four or five speed transmission except the fourth or fifth gear is overdrive instead of direct drive.)

B. Electrically operated planetary

IX. Major parts of the electrically operated overdrive (Transparency 9)

A. Planetary gearset

B. Governor

C. Shift solenoid

D. Relay

E. Kickdown switch

X. Operation of the electrically operated overdrive

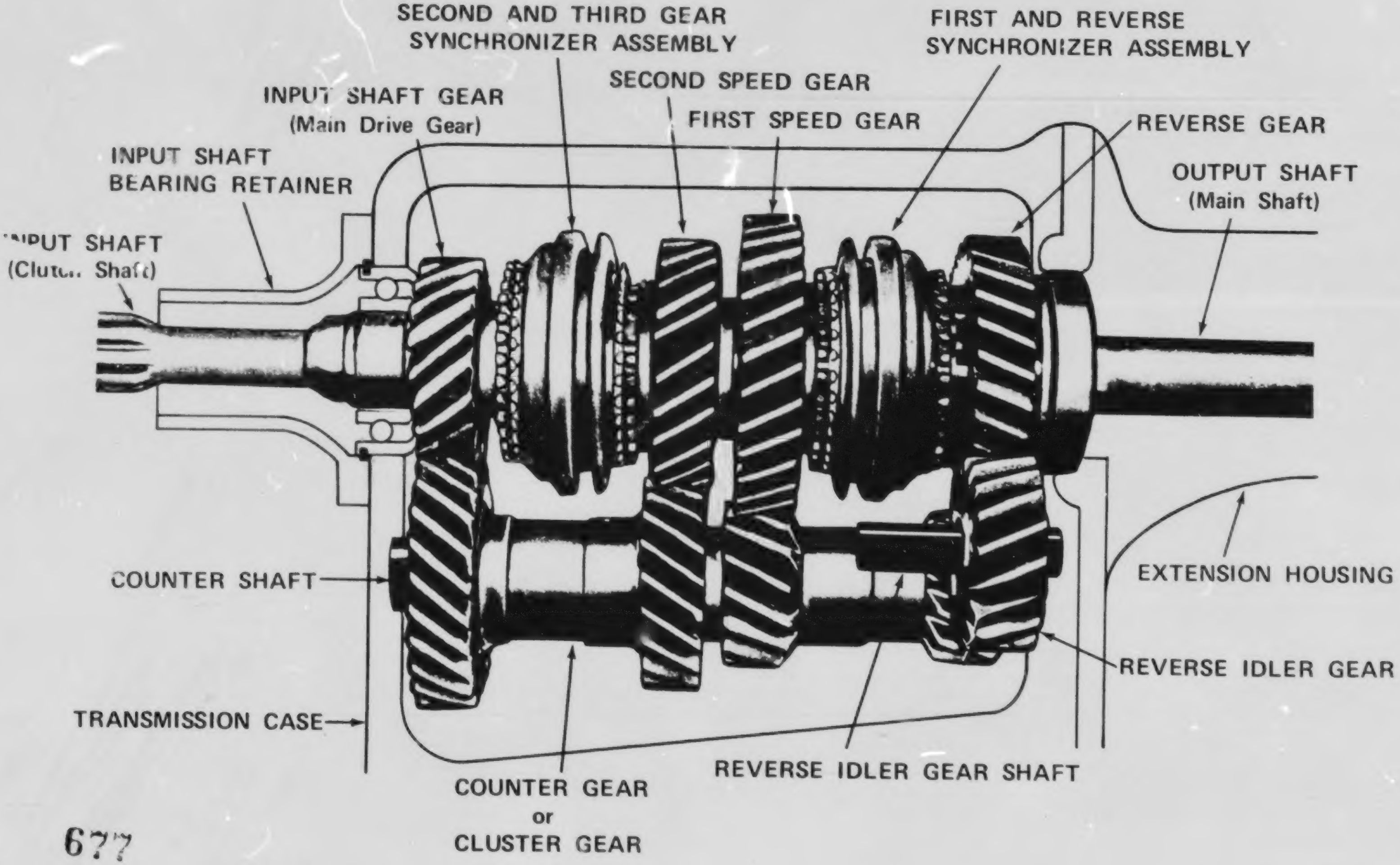
A. Overdrive unit starts in direct drive

B. At approximately 35 mph (54 km/h) the governor closes the electrical circuit for shifting into overdrive

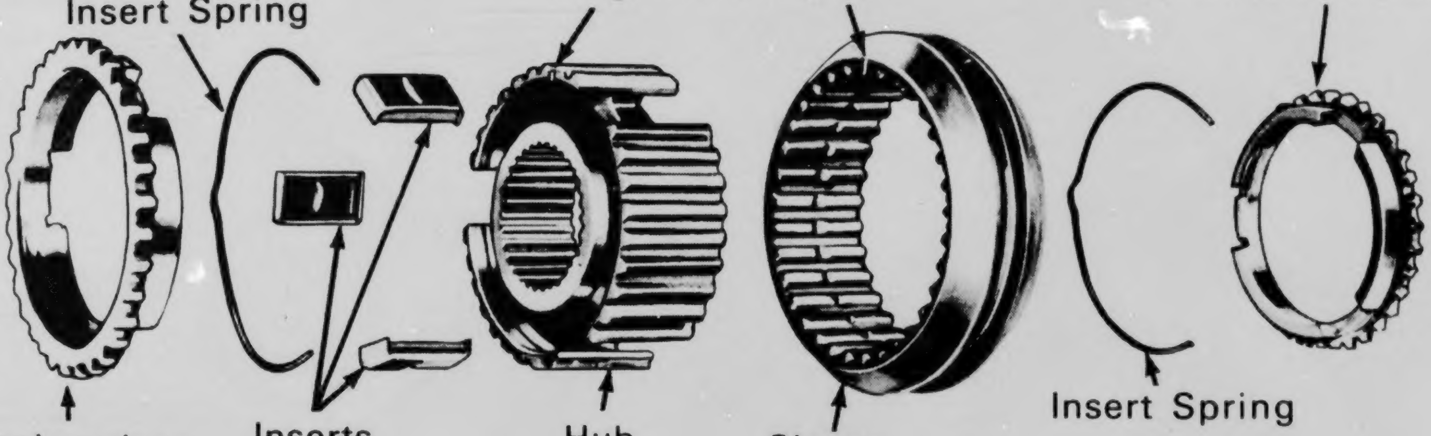
C. The driver momentarily lets up on the accelerator to relieve the pressure on the transmission and the shift is completed to overdrive speed

D. Downshift is accomplished by fully extending the accelerator pedal, causing the electrical circuit to shift the overdrive back to direct drive

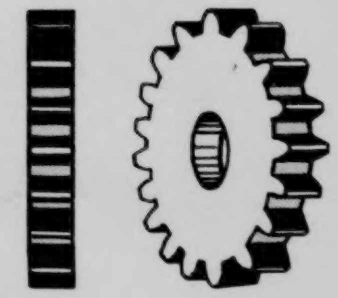
Parts of the Transmission


SECOND AND THIRD GEAR SYNCHRONIZER ASSEMBLY
FIRST AND REVERSE SYNCHRONIZER ASSEMBLY
SECOND SPEED GEAR
INPUT SHAFT GEAR (Main Drive Gear)
FIRST SPEED GEAR
REVERSE GEAR
INPUT SHAFT BEARING RETAINER
OUTPUT SHAFT (Main Shaft)
INPUT SHAFT (Clutch Shaft)
COUNTER SHAFT
EXTENSION HOUSING
REVERSE IDLER GEAR
TRANSMISSION CASE
REVERSE IDLER GEAR SHAFT
COUNTER GEAR or CLUSTER GEAR

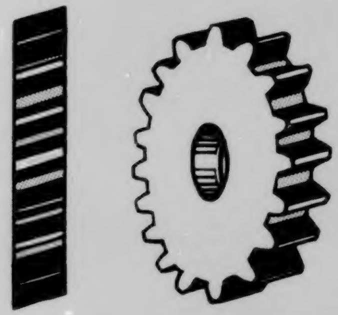
Parts of a Typical Synchronizer


Hub and Sleeve Alignment Marks
Synchronizer Ring
Insert Spring
Synchronizer Ring
Inserts
Hub
Sleeve
Insert Spring

Types of Gear Teeth used in a Standard Transmission

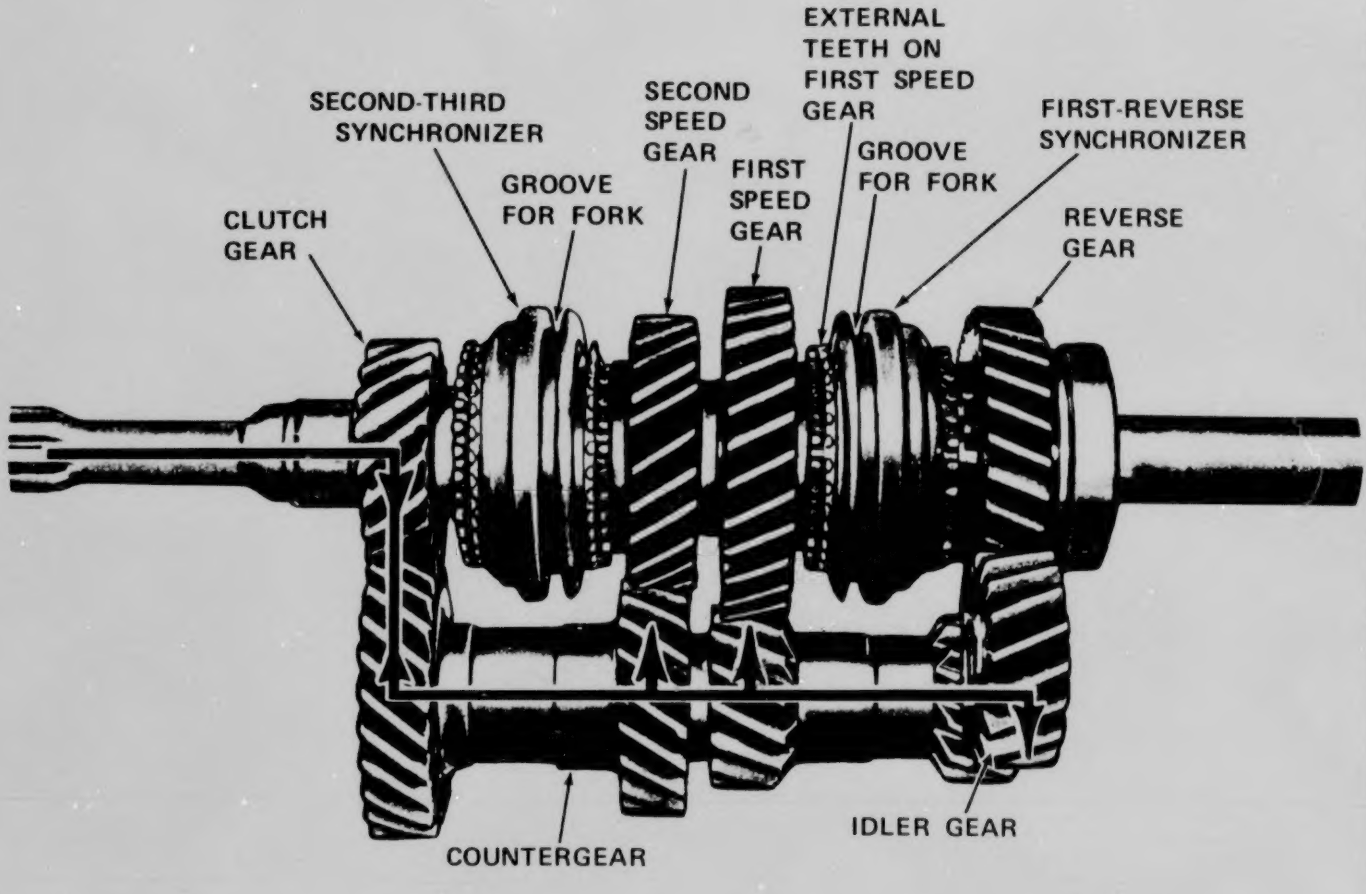


Spur Gear



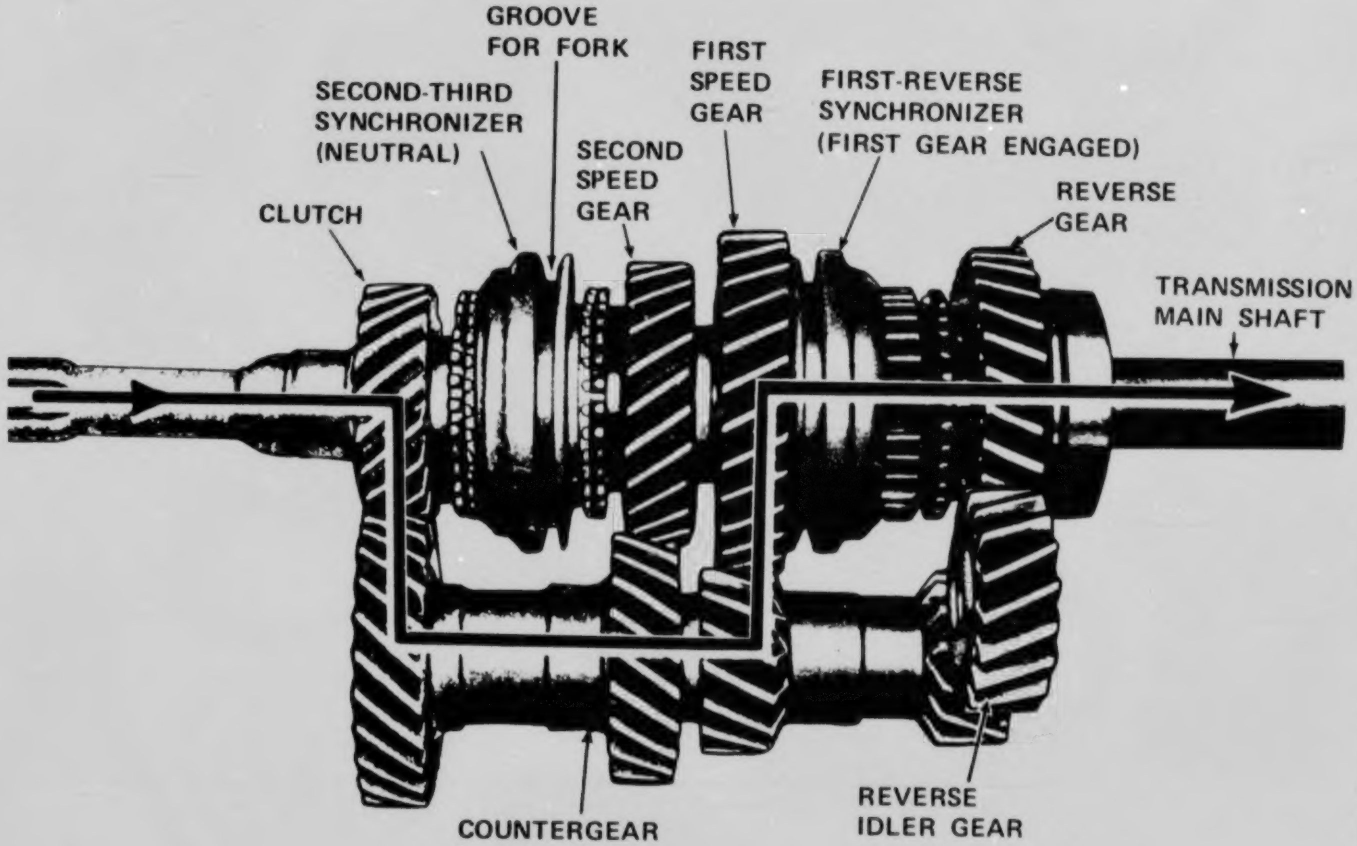
Helical Gear

Transmission Operation


SECOND-THIRD SYNCHRONIZER
SECOND SPEED GEAR
EXTERNAL TEETH ON FIRST SPEED GEAR
FIRST-REVERSE SYNCHRONIZER
GROOVE FOR FORK
FIRST SPEED GEAR
GROOVE FOR FORK
CLUTCH GEAR
REVERSE GEAR
IDLER GEAR
COUNTERGEAR

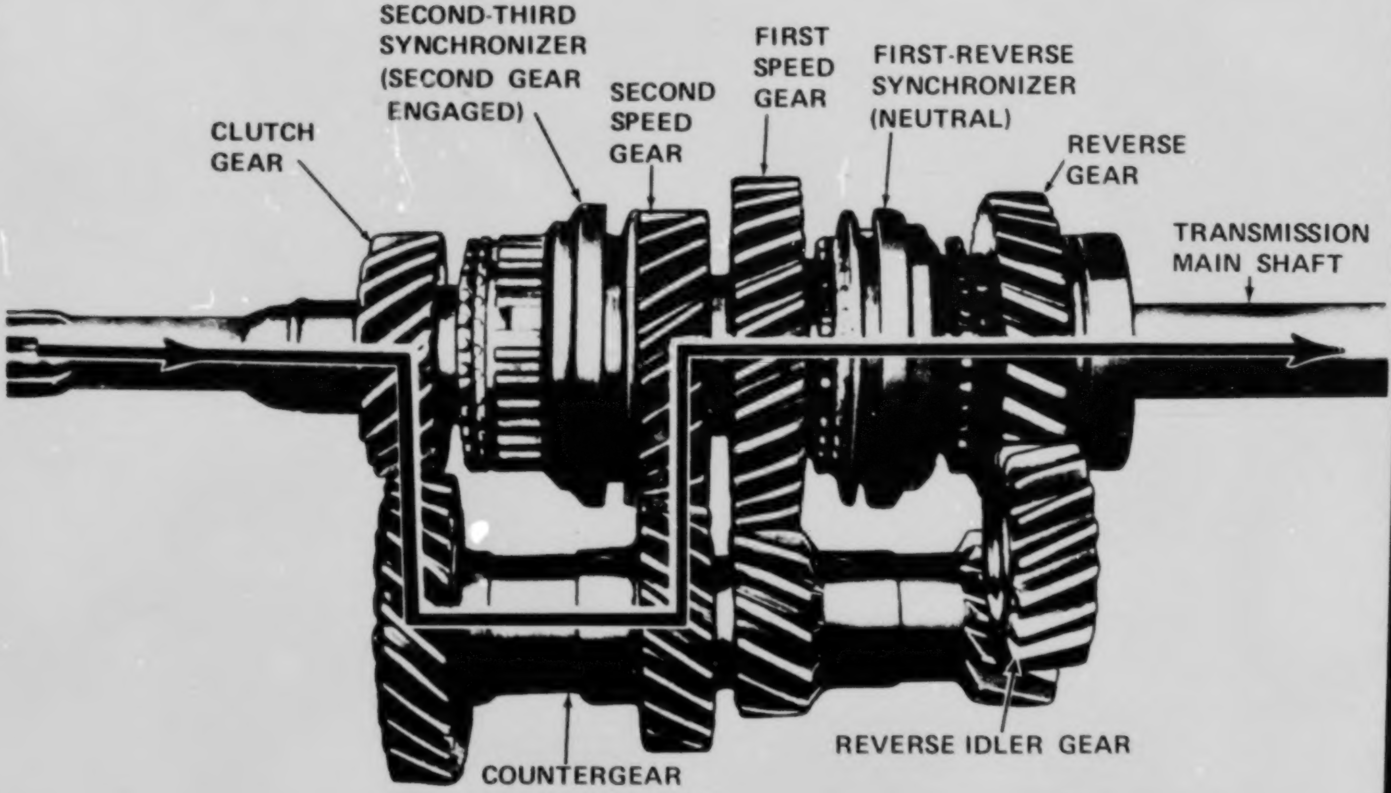
Neutral

Transmission Operation


GROOVE FOR FORK
SECOND-THIRD SYNCHRONIZER (NEUTRAL)
CLUTCH
SECOND SPEED GEAR
FIRST SPEED GEAR
FIRST-REVERSE SYNCHRONIZER (FIRST GEAR ENGAGED)
REVERSE GEAR
TRANSMISSION MAIN SHAFT
COUNTERGEAR
REVERSE IDLER GEAR

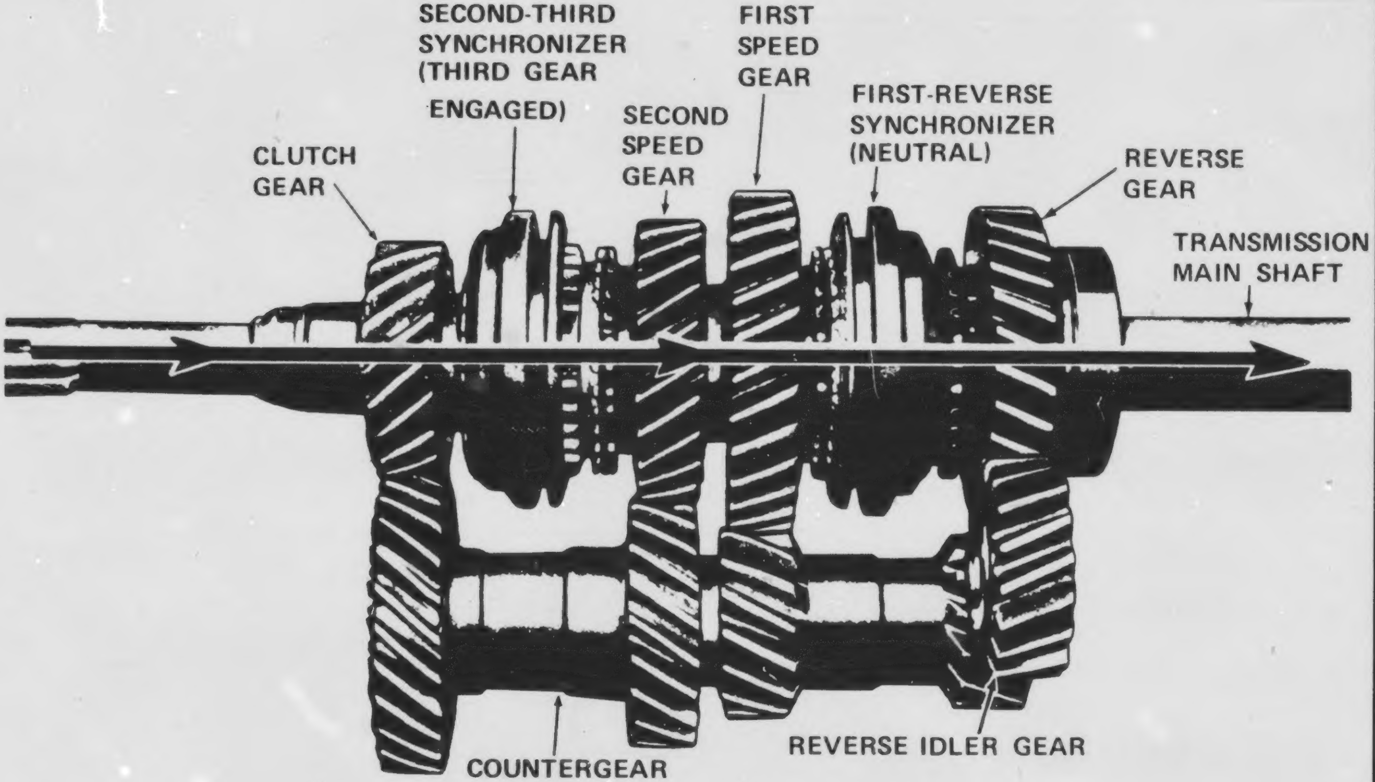
First Gear

Transmission Operation


SECOND-THIRD SYNCHRONIZER (SECOND GEAR ENGAGED)
FIRST SPEED GEAR
FIRST-REVERSE SYNCHRONIZER (NEUTRAL)
SECOND SPEED GEAR
CLUTCH GEAR
REVERSE GEAR
TRANSMISSION MAIN SHAFT
REVERSE IDLER GEAR
COUNTERGEAR

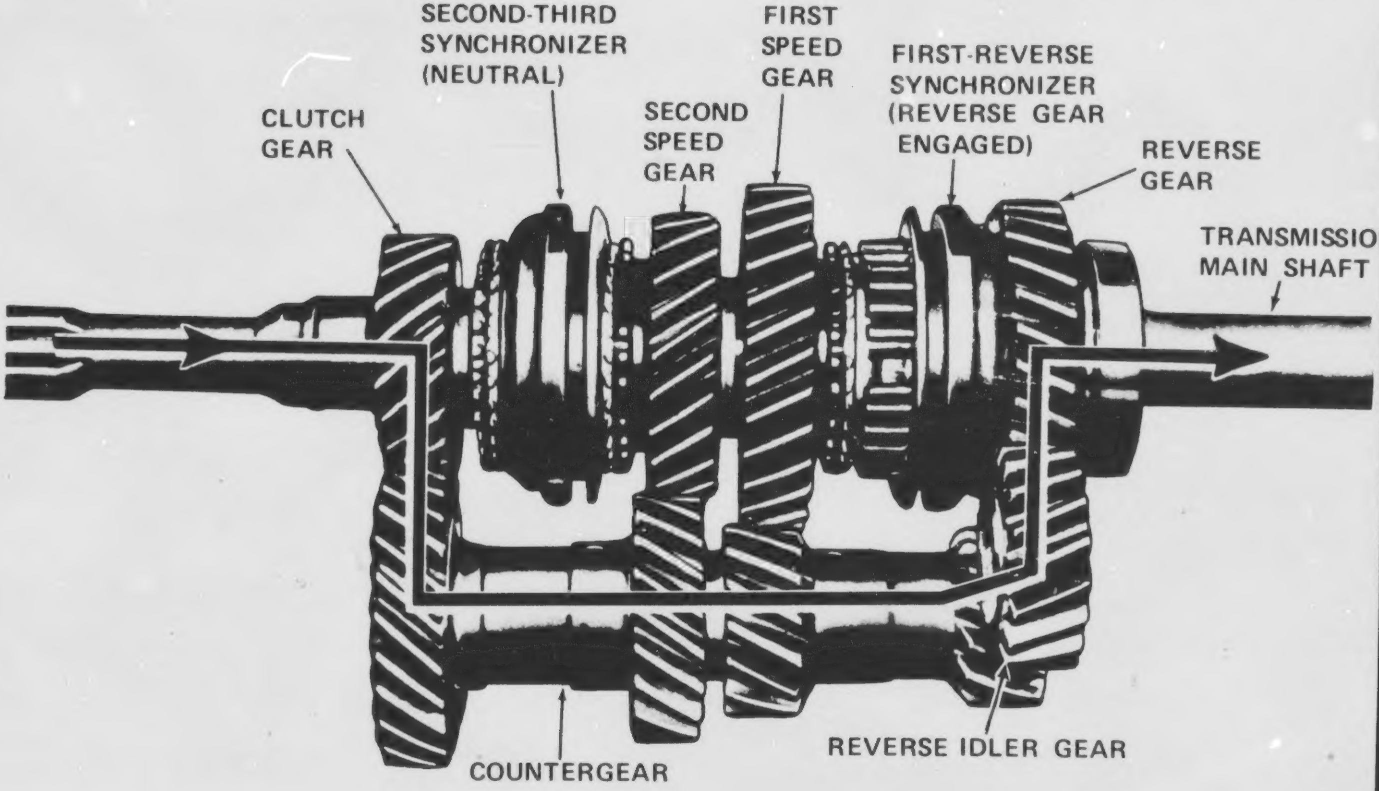
Second Gear

Transmission Operation


SECOND-THIRD SYNCHRONIZER (THIRD GEAR ENGAGED)
FIRST SPEED GEAR
FIRST-REVERSE SYNCHRONIZER (NEUTRAL)
SECOND SPEED GEAR
CLUTCH GEAR
REVERSE GEAR
TRANSMISSION MAIN SHAFT
COUNTERGEAR
REVERSE IDLER GEAR

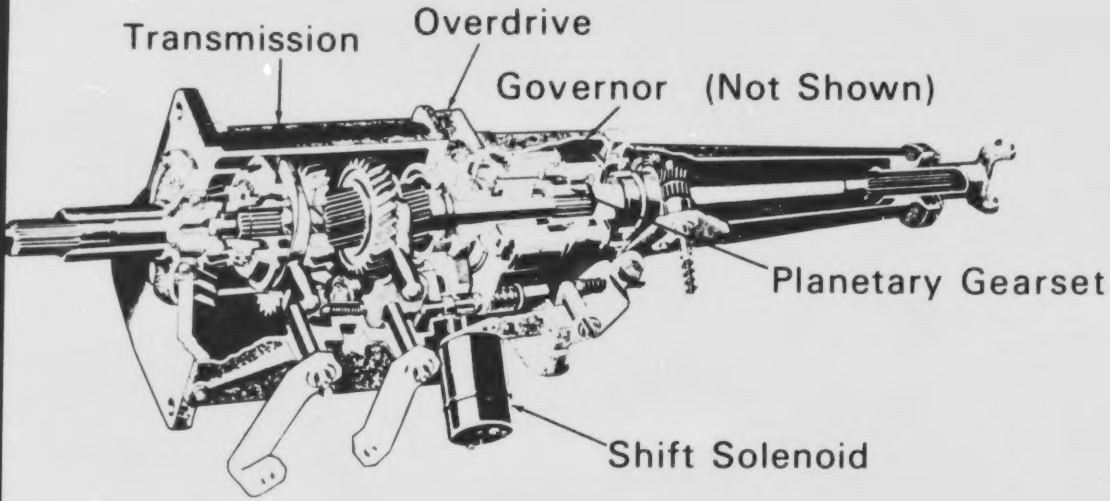
Third Gear

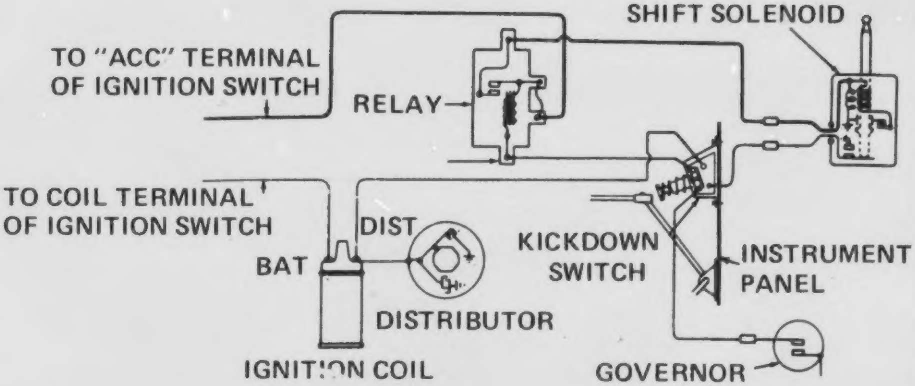
Transmission Operation


SECOND-THIRD
SYNCHRONIZER
(NEUTRAL)
FIRST
SPEED
GEAR
FIRST-REVERSE
SYNCHRONIZER
(REVERSE GEAR
ENGAGED)
CLUTCH
GEAR
SECOND
SPEED
GEAR
REVERSE
GEAR
TRANSMISSIO
MAIN SHAFT
REVERSE IDLER GEAR
COUNTERGEAR

Reverse

Parts of the Electrically Operated Overdrive


Transmission
Overdrive
Governor (Not Shown)
Planetary Gearset
Shift Solenoid


SHIFT SOLENOID
TO "ACC" TERMINAL
OF IGNITION SWITCH
RELAY
TO COIL TERMINAL
OF IGNITION SWITCH
DIST
BAT
KICKDOWN
SWITCH
INSTRUMENT
PANEL
DISTRIBUTOR
IGNITION COIL
GOVERNOR

Electrical Circuit Diagram

STANDARD TRANSMISSION
UNIT II

JOB SHEET #1--REMOVE AND REPLACE STANDARD TRANSMISSION

I. Tools and equipment

   A. Floor jack

   B. Jack stands

   C. Combination end wrenches, 3/8" - 3/4" (9 mm - 19 mm)

   D. Sockets, 7/16" - 3/4" (12 mm - 19 mm), 1/2" drive

   E. Ratchet, 1/2" drive

   F. Creeper

   G. Transmission jack

   H. Transmission alignment dowel pins

   I. Pliers

   J. Extensions, 6" and 10" (152 mm and 250 mm), 1/2" drive

   K. Small hydraulic jack

   L. Suitable wood blocks, 2" x 4" x 6" (5.8 cm x 12.7 cm x 15.24 cm)

II. Procedure

   A. Remove transmission

      1. Support vehicle on jack stands

         (NOTE: Jack stands should be placed under frame so that there is adequate working room for transmission removal.)

      2. Remove the shift linkage

         (NOTE: Mark shift linkage to facilitate assembly.)

      3. Remove the speedometer cable

      4. Remove any wires, linkage, or brackets attached to the transmission

      5. Place reference marks on propeller shaft and pinion flange for reinstallation

      6. Remove the propeller shaft attaching bolts as required

JOB SHEET #1

7. Remove the propeller shaft

   (NOTE: Use care to avoid dropping the roller assemblies of the U-joint.)

8. Place a propeller shaft yoke in the rear of the transmission to prevent oil from spilling during removal

9. Support the rear of the engine with a small jack and wooden blocks if a rear crossmember and transmission mount are used

10. Remove crossmember and rear mounting bolts

11. Remove crossmember as required

12. Remove the transmission attaching bolts

13. Install transmission alignment dowel pins

    (NOTE: Alignment dowel pins should be long enough to provide support until input shaft is clear of the clutch disc.)

14. Remove transmission

    (NOTE: Use transmission jack to aid removal.)

B. Service transmission as required

C. Replace transmission

1. Place transmission into clutch housing

   (NOTE: Make sure release bearing is in place.)

2. Remove alignment dowel pins and replace transmission attaching bolts

3. Tighten transmission bolts securely; torque to manufacturer's specifications

4. Install rear crossmember and transmission mount as required

5. Remove engine support jack and wooden blocks

6. Remove propeller shaft yoke used to prevent oil leakage from rear of transmission

7. Replace propeller shaft while aligning reference marks

8. Start propeller shaft attaching bolts

JOB SHEET #1

9. Tighten propeller shaft bolts securely; torque to manufacturer's specifications

10. Install shift linkage

    (NOTE: Make sure the linkage does not bind and that it is properly attached.)

11. Install speedometer cable

12. Install wires, brackets, and linkages as required

13. Fill transmission with proper lubricant

14. Remove jack stands and lower car to floor

STANDARD TRANSMISSION
UNIT II

JOB SHEET #2--DISASSEMBLE, INSPECT, AND REASSEMBLE A THREE-SPEED TRANSMISSION

I. Tools and equipment

A. Basic hand tool set

B. Drift punch (brass)

C. Light grease

D. Drain pan

E. Snap ring pliers

F. Safety glasses

G. Clean shop towels

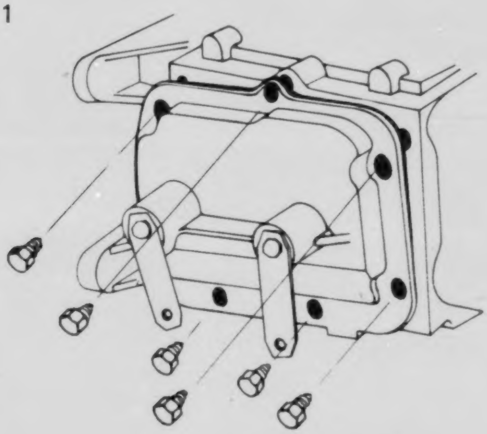
II. Procedure

(NOTE: This job sheet is written for a Saginaw three-speed fully synchronized transmission.)

A. Disassemble transmission

1. Drain the transmission lubricant
2. Clean the outside of the transmission thoroughly
3. Remove the side cover attaching bolts (Figure 1)
4. Remove side cover assembly (Figure 1)

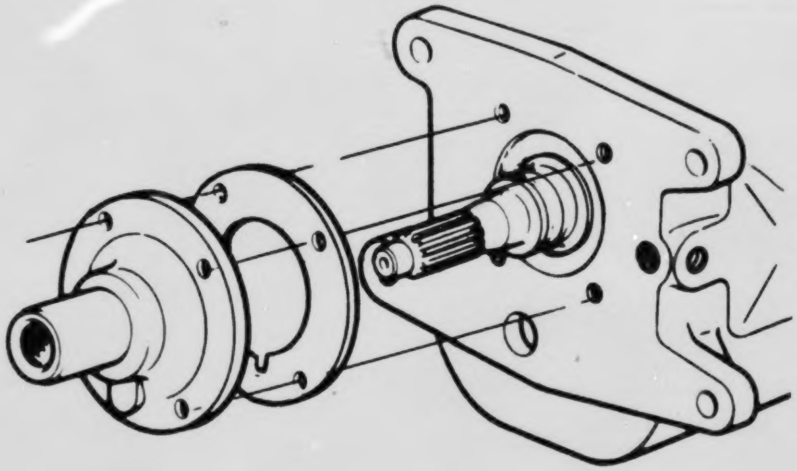
FIGURE 1



JOB SHEET #2

5. Remove input shaft bearing retainer and gasket (Figure 2)

FIGURE 2

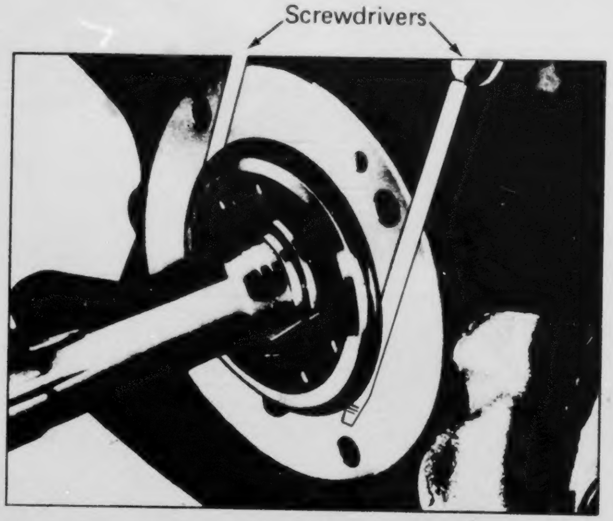


6. Remove input shaft bearing (Figure 3)
    - a. Remove snap ring from shaft
    - b. Pull outward on input shaft
    - c. Insert screwdrivers or suitable tool between bearing outer snap ring and case

JOB SHEET #2

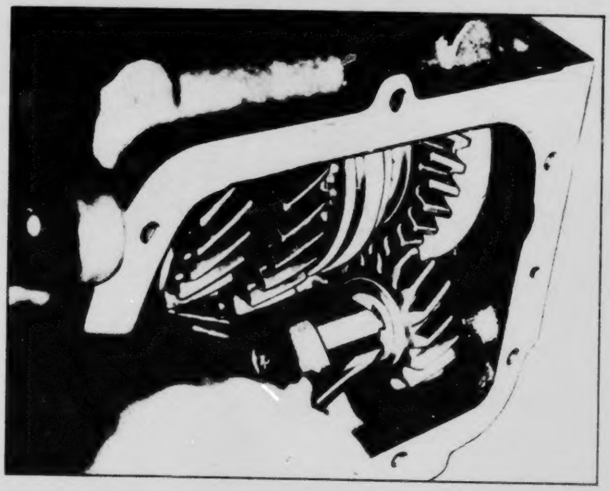
d. Tap inward on the input shaft with a soft hammer while holding the screwdrivers in place to remove bearing

FIGURE 3



7. Remove speedometer gear from extension housing
8. Remove extension housing attaching bolts
9. Remove the reverse idler shaft E-ring (Figure 4)

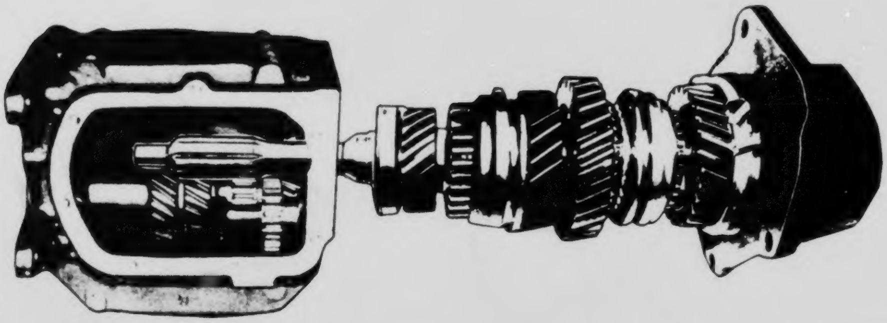
FIGURE 4



JOB SHEET #2

10. Remove the input shaft, output shaft, and extension housing as an assembly through the rear opening of the case (Figure 5)

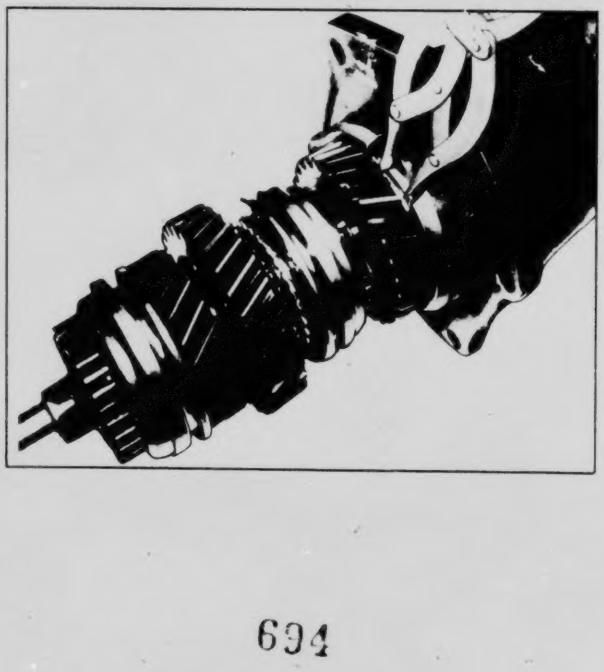
FIGURE 5



11. Remove the input shaft, needle bearings, and synchronizer ring from the output shaft

12. Expand the snap ring in the extension housing which retains the output shaft bearing (Figure 6)

FIGURE 6



JOB SHEET #2

13. Remove the bearing and shaft assembly from the extension housing by tapping on the splined end of the shaft with a soft hammer

14. Disassemble output shaft assembly (Figure 7)

    a. Remove snap ring retaining second and third gear synchronizer

    b. Remove synchronizer assembly

    c. Remove second gear

    d. Remove speedometer gear

    e. Remove snap ring retaining output shaft rear bearing

    f. Press rear bearing off shaft

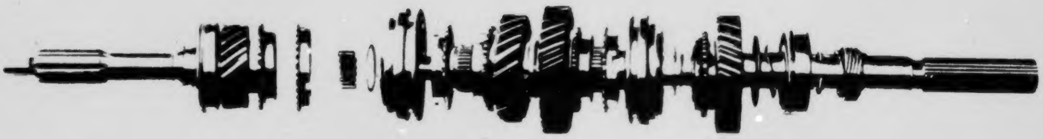
    g. Remove reverse gear

    h. Remove snap ring retaining first and reverse synchronizer

    i. Remove first and reverse synchronizer

    j. Remove first gear

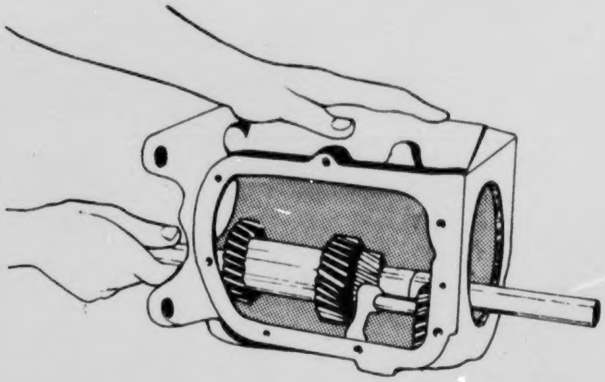
FIGURE 7



JOB SHEET #2

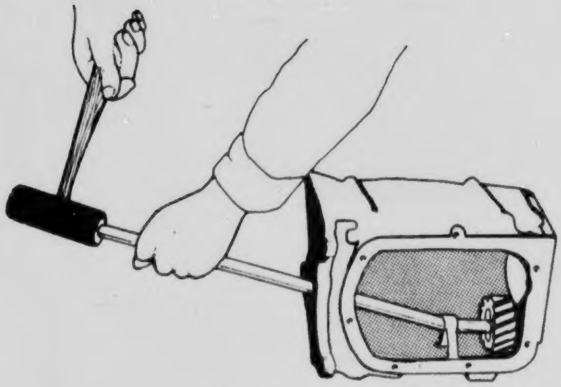
15. Remove counter shaft and its woodruff key by driving it out of the case from front to rear with a brass drift slightly smaller than the counter shaft (Figure 8)

FIGURE 8



16. Remove reverse idler gear shaft with a long drift through the front of the case (Figure 9)

FIGURE 9



JOB SHEET #2

B. Clean and inspect all parts

1. Wash the bearings in clean solvent
2. Blow out the bearings with compressed air

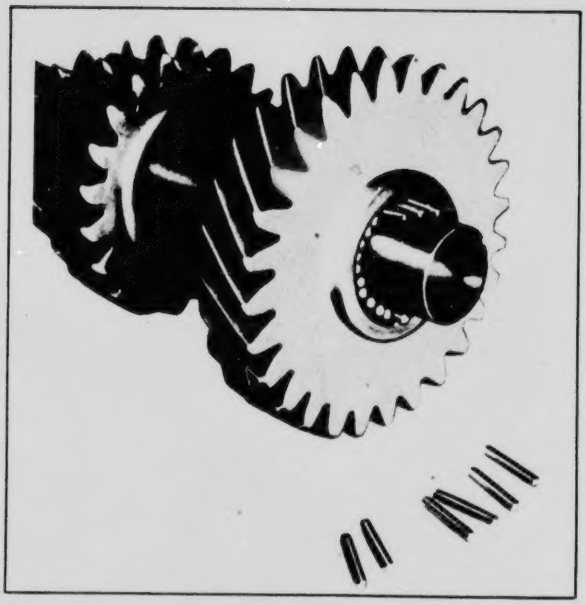
   (CAUTION: Do not let the bearings spin.)
3. Check bearings for roughness
4. Clean and inspect the transmission case
5. Clean and inspect all gears for wear or damage
6. Inspect synchronizer assemblies for excessive wear
7. Replace all parts showing damage or wear

C. Reassemble transmission

1. Load a row of roller (needle) bearings and a bearing thrust washer at each end of the counter gear (Figure 10)

   (NOTE: The bearings can be loaded either with the aid of a loading shaft or by using grease to hold the parts in place during assembly.)

FIGURE 10



JOB SHEET #2

2. Place the loaded counter gear in the case through the rear opening
3. Install tanged thrust washers in the case with tangs towards case
4. Install counter gear in place in the case
5. Install counter shaft and its woodruff key

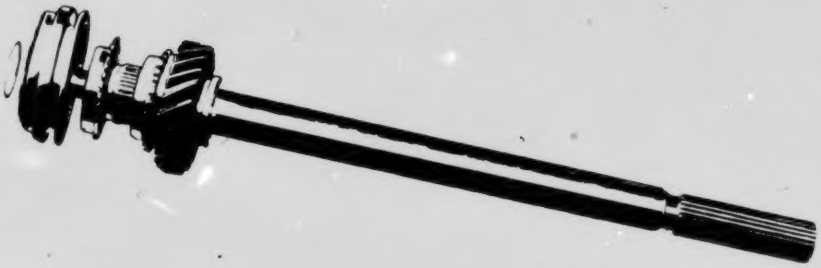
   (CAUTION: Be sure counter shaft picks up both thrust washers and that both tangs are aligned with their notches in the case.)

6. Install reverse idler gear and shaft with its woodruff key from the rear of case

   (NOTE: Do not install the idler shaft E-ring at this time.)

7. Assemble the output shaft
   a. Turn the output shaft front end upward
   b. Install the second speed gear with clutch teeth upward and the rear gear face butted against the output shaft flange (Figure 11)

FIGURE 11



   c. Install a synchronizer ring with clutch teeth downward over synchronizer surface of second speed gear
   d. Install second and third synchronizer assembly with fork groove downward

JOB SHEET #2

e. Press synchronizer assembly on the output shaft enough to install retaining snap ring into its groove

(CAUTION: Be sure the synchronizer ring notches align with the keys.)

f. Install snap ring

g. Turn the rear of the input shaft upward

(NOTE: Refer to Figure 12 for steps *a* through *i*.)

h. Install the first speed gear with clutching teeth upward

(NOTE: The front face of the gear will butt against the flange of the output shaft.)

i. Install synchronizer ring with clutching teeth downward over synchronizing face of first speed gear

j. Install the first and reverse synchronizer assembly with fork groove downward

k. Install retaining snap ring

(CAUTION: Be sure the notches of the synchronizer ring align with the keys of the synchronizer assembly.)

l. Install reverse gear with clutching teeth downward

m. Install reverse gear thrust washer (steel)

n. Install reverse gear spring washer

o. Install rear bearing with snap ring slot downward

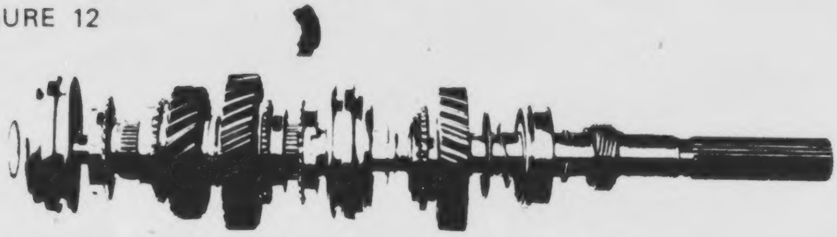
p. Press bearing into place on the output shaft

q. Install output shaft to rear bearing snap ring

JOB SHEET #2

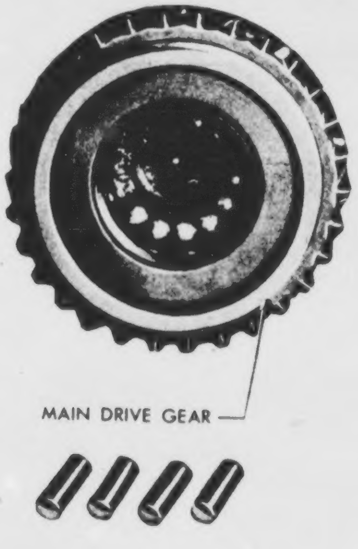
r. Install speedometer drive gear and retaining clip

FIGURE 12



8. Install output shaft assembly in extension housing
   a. Place the splined end of the shaft through the front opening in the housing
   b. Start the rear ball bearing in its bore in the housing
   c. Expand the snap ring enough to allow bearing to slip through
   d. Tap shaft and bearing assembly in so the snap ring will fit in its groove in the bearing outer race
9. Install speedometer gear in the extension housing
10. Load roller bearings in main drive gear (Figure 13)

FIGURE 13



JOB SHEET #2

11. Install a synchronizer ring with clutching teeth over the synchronizing surface of the main drive gear

12. Install main drive gear and synchronizer ring on the output shaft

    (CAUTION: Be sure to align the notches in the synchronizer ring with the keys in the synchronizer assembly.)

13. Place extension to case gasket at rear of case holding it in place with grease

14. Install the input shaft, output shaft, and extension housing as an assembly into the case through the rear opening of the case

15. Install extension housing to case retaining bolts

16. Install snap ring in outer groove of input shaft bearing

17. Position bearing over stem of input shaft and into front of case bore

18. Install snap ring in input shaft groove

19. Install bearing retainer and gasket on case over the input shaft

    (NOTE: The retainer oil return hole should be at the bottom.)

20. Install reverse idler gear retainer E-ring to shaft

21. Install cover, gasket, and fork assembly to case

    (NOTE: Be sure forks align with their synchronizer sleeve grooves.)

22. Torque all bolts to specifications

23. Rotate input shaft and shift transmission to check for free rotation in all gears

STANDARD TRANSMISSION
UNIT II

TEST

NAME ______________________________ SCORE ____________________

1. State the purpose of a transmission.

____

____

____

2. Match the terms on the right to the correct definitions.

_____a. Turning or twisting effort

_____b. Gears that are always in mesh with each other

_____c. Device in the transmission that brings two gears being shifted together to rotate at the same speed

_____d. Relationship between the number of turns made by a driving gear to complete one full turn of the driven gear

_____e. Gear in the transmission used to change direction of rotation of the output shaft

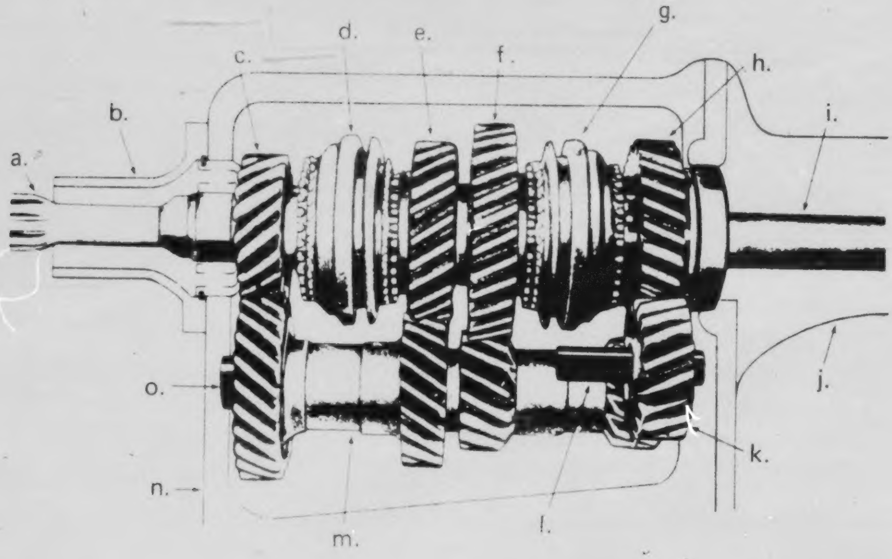
_____f. Transmission using synchronizers that prevent grinding of gear teeth while shifting gears

_____g. Group of gears made on a common casting; used in a standard transmission to connect the main drive gear to the first, second, and reverse idler gears

_____h. Gear that rotates backward

1. Synchronizer
2. Gear ratio
3. Idler gear
4. Torque
5. Synchromesh transmission
6. Cluster gear
7. Constant mesh
8. Counter gear

3. Identify the following parts of a transmission.


a.
b.
c.
d.
e.
f.
g.
h.
i.
j.
k.
l.
m.
n.
o.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

h. ______________________________

i. ______________________________

j. ______________________________

k. ______________________________

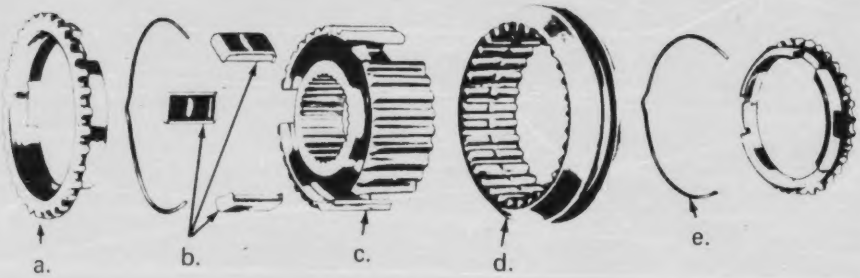
l. ______________________________

m. ______________________________

n. ______________________________

o. ______________________________

4. Identify the parts of the synchronizer below.



a. ____________ d. ____________

b. ____________ e. ____________

c. ____________

5. List the types of gear teeth commonly used in a standard transmission.

a. ____

b. ____

6. Discuss the operation of a three-speed synchromesh transmission.

a. Neutral-- ____

____

____

b. First gear-- ____________________

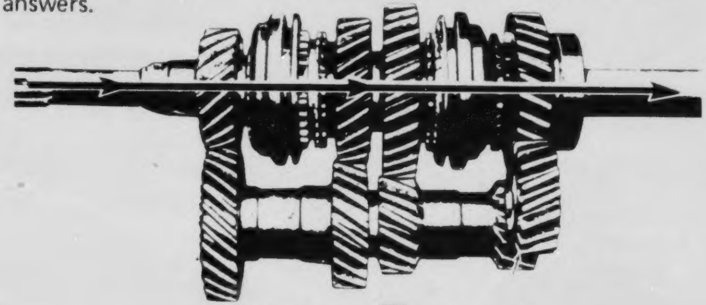
c. Second gear- ____________________

d. Third gear-- ____________________

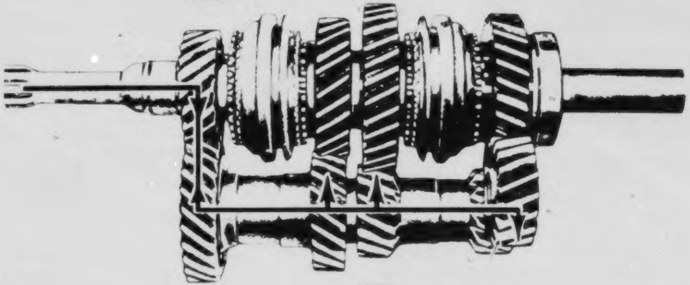
e. Reverse gear-- ____________________

7. Select the gear in which each of the following transmissions is positioned. Circle the correct answers.

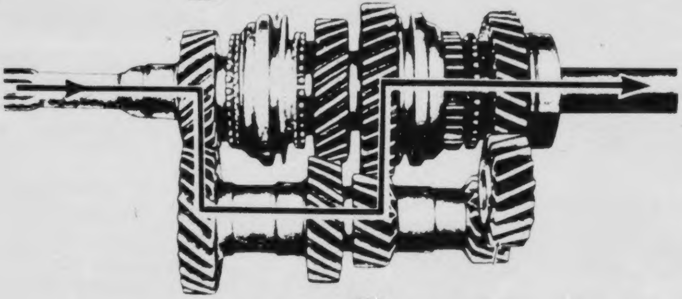
a. 1) Neutral
2) First
3) Second
4) Third
5) Reverse



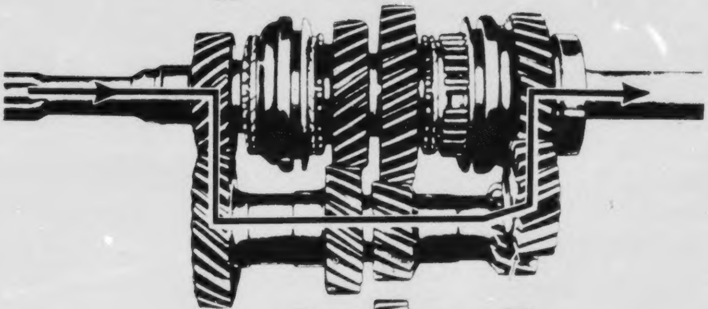
b. 1) Neutral
2) First
3) Second
4) Third
5) Reverse



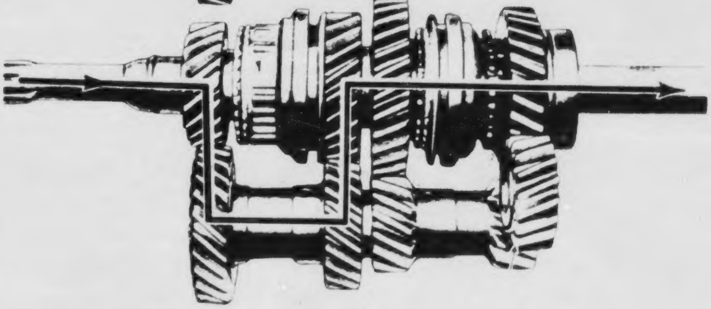
c. 1) Neutral
2) First
3) Second
4) Third
5) Reverse



d. 1) Neutral
2) First
3) Second
4) Third
5) Reverse



e. 1) Neutral
2) First
3) Second
4) Third
5) Reverse

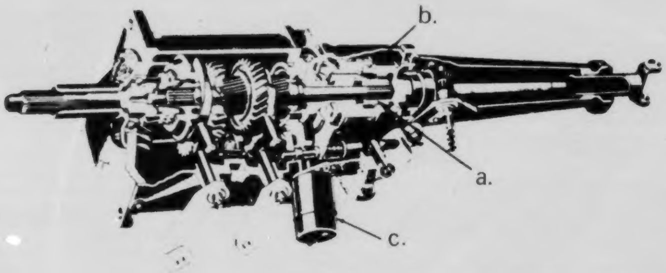


8. List two types of overdrives.

a. ____________________

b. ____________________

9. Identify the major parts of an electrically operated overdrive by writing the correct names in the blanks provided.



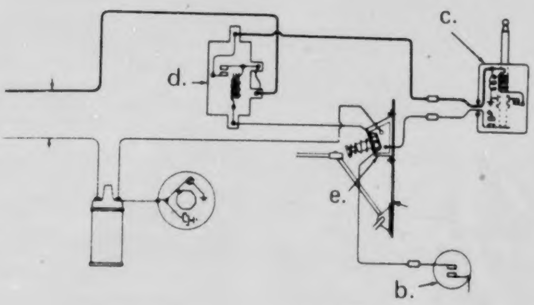
a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________



10. Discuss the operation of an electrically operated overdrive.

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11. Demonstrate the ability to:

    a. Remove and replace a standard transmission.

    b. Disassemble, inspect, and reassemble a three-speed transmission.

    (NOTE: If the above activities have not been accomplished prior to the test, ask the instructor when they should be completed.)

STANDARD TRANSMISSION
UNIT II

ANSWERS TO TEST

1. To provide a method of varying the gear ratio between the engine and rear wheels and to provide a reverse

2. a. 4

   b. 7

   c. 1

   d. 2

   e. 3

   f. 5

   g. 6

   h. 8

3. a. Input shaft (clutch shaft)

   b. Input shaft bearing retainer

   c. Input shaft gear (main drive gear)

   d. Second and third gear synchronizer assembly

   e. Second speed gear

   f. First speed gear

   g. First and reverse synchronizer assembly

   h. Reverse gear

   i. Output shaft (main shaft)

   j. Extension housing

   k. Reverse idler gear

   l. Reverse idler gear shaft

   m. Counter or cluster gear

   n. Transmission case

   o. Counter shaft

4. a. Synchronizer ring
   b. Inserts
   c. Hub
   d. Sleeve
   e. Insert spring

5. a. Spur gear
   b. Helical gear

6. Discussion should include:

   a. Neutral--Input shaft drives the cluster gear which in turn drives the constant mesh second and reverse idler gear; no power is transmitted

   b. First gear--First and reverse synchronizer sleeve is moved to engage first gear; power is transmitted from the input shaft to cluster gear, to first gear, and on to output shaft

   c. Second gear--Second and third gear synchronizer sleeve is moved to engage second gear; power is transmitted from the input shaft to cluster gear, to second gear, and on to output shaft

   d. Third gear--Second and third gear synchronizer sleeve is moved to engage third gear; power is transmitted from the input shaft to the output shaft

   e. Reverse gear--First and reverse synchronizer sleeve is moved to engage reverse idler gear; power is transmitted from the input shaft to the cluster gear; cluster gear drives the reverse idler gear; reverse idler gear drives the reverse gear and output shaft in a direction opposite engine rotation

7. a. Third
   b. Neutral
   c. First
   d. Reverse
   e. Second

8. a. Manual fourth gear
   b. Electrically operated planetary

9. a. Planetary gearset

   b. Governor

   c. Shift solenoid

   d. Relay

   e. Kickdown switch

10. Discussion should include:

    a. Overdrive unit starts in direct drive

    b. At approximately 35 mph (54 km/h) the governor closes the electrical circuit for shifting into overdrive

    c. The driver momentarily lets up on the accelerator to relieve the pressure on the transmission and the shift is completed to overdrive speed

    d. Downshift is accomplished by fully extending the accelerator pedal, causing the electrical circuit to shift the overdrive back to direct drive

11. Performance skills evaluated to the satisfaction of the instructor

DRIVE LINES
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify types and components of the drive lines. The student should be able to remove, repair, balance, and align angles of the propeller shaft. This knowledge will be evidenced through demonstration and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with drive lines to the correct definitions.
2. Identify the types of drive lines.
3. Identify the components of a propeller shaft.
4. Identify the types of U-joints.
5. Identify the parts of a cross and roller or cardan U-joint.
6. Identify the parts of a ball and trunnion U-joint.
7. Identify the parts of a constant velocity U-joint.
8. Discuss the acceleration-deceleration of a propeller shaft equipped with cross and roller U-joint.
9. Identify major components of a four wheel drive.
10. Identify tools used in drive line repair.
11. List methods of controlling drive line vibration.
12. Demonstrate the ability to:
    a. Remove and replace a propeller shaft.
    b. Remove and replace a cross and roller U-joint.
    c. Remove and replace a ball and trunnion U-joint.
    d. Balance a propeller shaft.
    e. Check and adjust U-joint angles.

DRIVE LINES
UNIT III

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information sheet.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss procedures outlined on the job sheets.

   G. Give test.

II. Unit references:

   A. Crouse, William H., and Anglin, Donald L. *Automotive Transmissions and Power Trains*. 5th ed. New York: Gregg Div./McGraw-Hill Book Co., 1976.

   B. Crouse, William H. *Automotive Mechanics.* 7th ed. New York: McGraw-Hill Book Co., 1975.

   C. *Ford Service Manual.* Dearborn, Michigan: Ford Motor Co., 1975-76.

   D. *Chrysler, Plymouth, Dodge Chassis Manual*. Detroit: Chrysler Corp., 1976.

   E. *Chevrolet Service Manual*. Detroit: Chevrolet Motor Div./General Motors Corp., 1977.

DRIVE LINES
UNIT III

INFORMATION SHEET

I. Terms and definitions

A. Drive line--Driving connection made up of one or more propeller shafts between transmission and differential (Transparency 1)

B. Propeller shaft--Shaft that connects the transmission to the rear axle to propel the vehicle (Transparency 2)

C. U-joint (universal joint)--Coupling that allows power to be transferred through an angle (Transparency 3)

D. Constant velocity U-joint--Two closely coupled cross and roller U-joints arranged so that their acceleration-deceleration effects cancel each other, resulting in output propeller shaft speed identical to input speed (Transparency 3)

E. Slip joint--Variable-length connection at one end of a propeller shaft that allows the shaft to vary in length as the vehicle body moves up and down in relation to the rear axle

F. Cardan joint--Cross and roller U-joint (Transparency 4)

(NOTE: It is also called a *Hooke joint*.)

G. Whirl--Propeller shaft runout or unbalanced condition causing the shaft to act similar to the looping action of a rope held at both ends and swung in an arc

H. U-joint timing--Procedure of aligning the yokes of a two or more piece propeller shaft to help control whirl and vibration in the propeller shaft (Transparency 2)

II. Types of drive lines (Transparency 1)

A. Hotchkiss drive (open propeller shaft)

(NOTE. The Hotchkiss drive has either a one or two piece propeller shaft.)

B. Torque-tube drive (closed propeller shaft)

(NOTE. The torque-tube drive has been replaced by the more common Hotchkiss drive.)

INFORMATION SHEET

III. Components of a propeller shaft (Transparency 2)

   A. Torsional damper

   B. U-joint

   C. Shaft

   D. Center bearing support (carrier bearing)

   E. Slip joint

   F. Balance weight

IV. Types of U-joints (Transparency 3)

   A. Cross and roller

   B. Ball and trunnion

   C. Rzeppa

   (NOTE: This type of U-joint is mainly used on front wheel drives.)

   D. Constant velocity

V. Parts of a cross and roller or cardan U-joint (Transparency 4)

   A. Yoke

   B. Cross

   C. Roller

   D. Needle bearings

   E. Seal

   F. Snap ring

VI. Parts of a ball and trunnion U-joint (Transparency 5)

   A. U-joint housing

   B. Trunnion pin

   C. Ball

   D. Needle bearings

   E. Button spring

INFORMATION SHEET

F. Gasket

G. Grease cover

H. Boot

I. Clamps

J. Centering button

K. Thrust washer

(NOTE: A three-ball and trunnion joint has been developed for front wheel drive axles where extreme operating angles are required.)

VII. Parts of a constant velocity U-joint (Transparency 6)

A. Snap ring

B. Roller and seal

C. Ball seat assembly

D. Ball spring

E. Ball support yoke

F. Link yoke

G. Centering ball assembly

H. Ball stud

I. Ball tube yoke

VIII. Acceleration-deceleration of propeller shaft equipped with cross and roller U-joint (Transparency 7)

A. Input side of joint turns at constant speed

B. Output side of the joint accelerates and decelerates twice during one revolution of the shaft

C. The greater the U-joint running angle is, the greater the effect will be

IX. Major components of a four wheel drive (Transparency 8)

A. Front propeller shaft

B. Transfer case

INFORMATION SHEET

C. Rear propeller shaft

(NOTE: On some vehicles an additional propeller shaft may be located between the transmission and transfer case.)

X. Tools used in drive line repair (Transparency 9)

A. Dial indicator

B. Hydraulic press tool

C. U-joint hand press

D. Inclinometer

XI. Methods of controlling drive line vibration (Transparency 10)

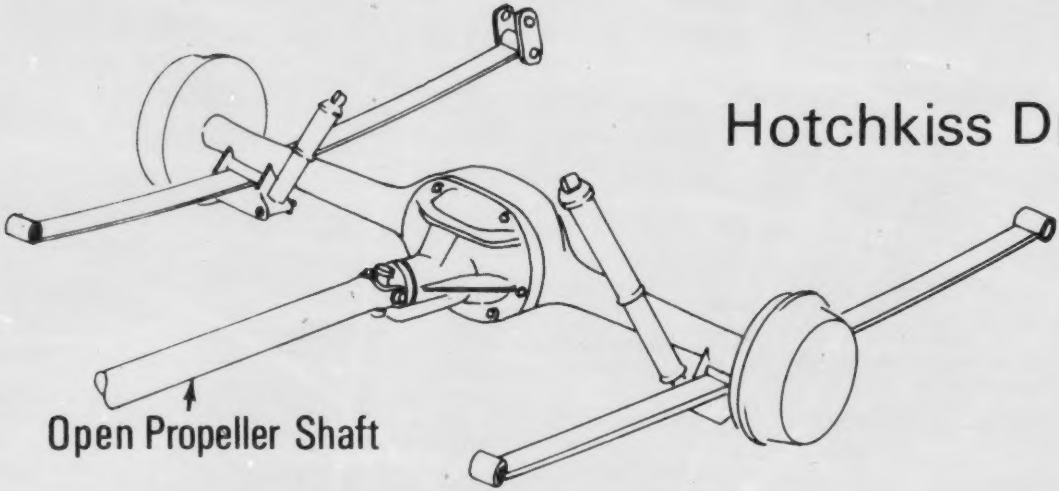
A. Elastomer sleeved propeller shaft

B. Torsional vibration damper

C. Constant velocity U-joint

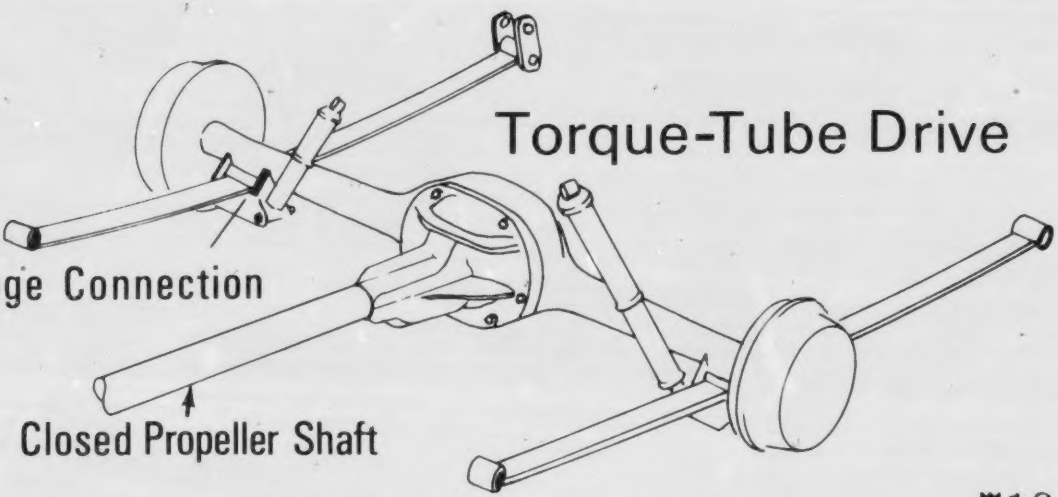
D. Vibration absorber

Types of Drive Lines



Hotchkiss Drive

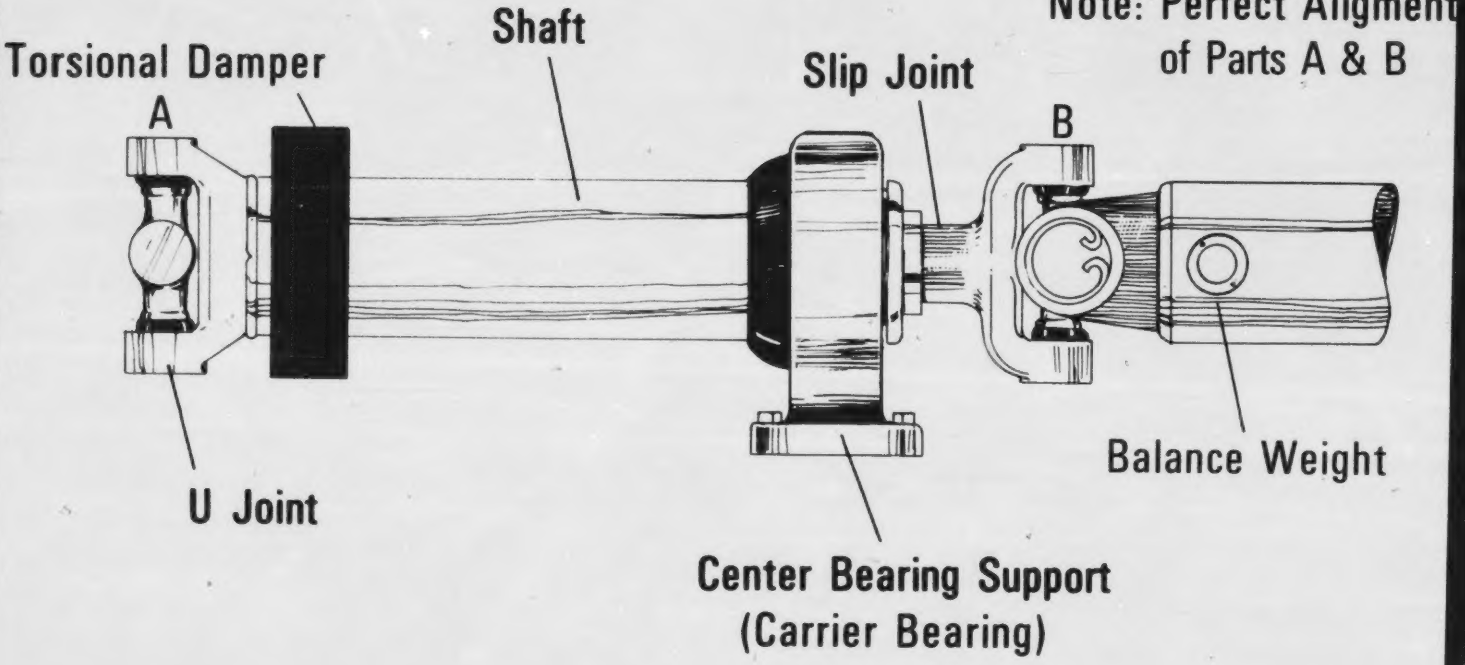
Open Propeller Shaft



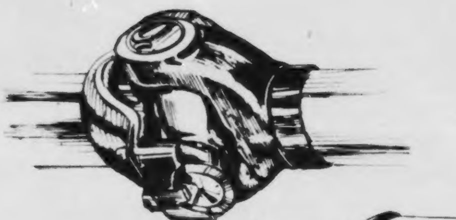
Torque-Tube Drive

Hinge Connection
Closed Propeller Shaft

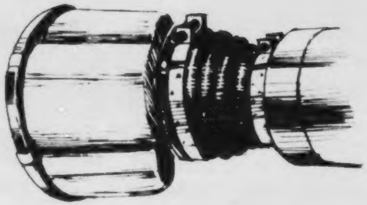
Propeller Shaft Components


Torsional Damper
A
Shaft
Slip Joint
Note: Perfect Aligment
of Parts A & B
B
U Joint
Center Bearing Support
(Carrier Bearing)
Balance Weight

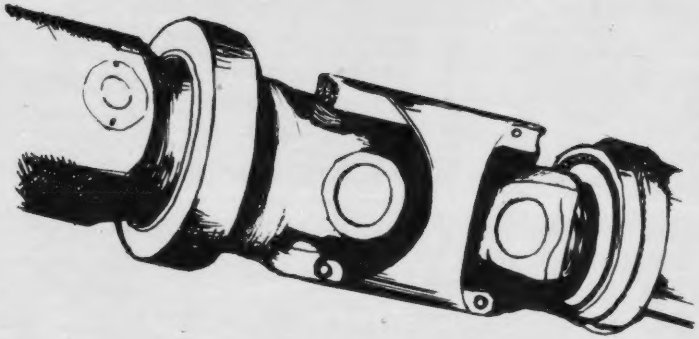
Types of U-Joints



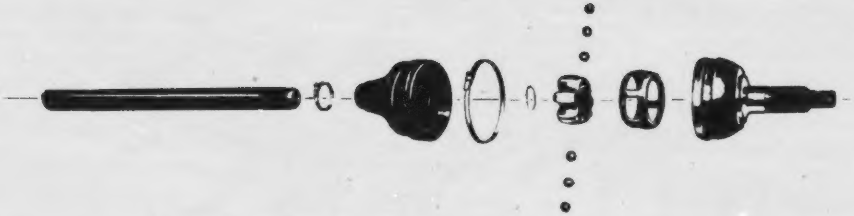
Cross and Roller



Ball and Trunnion

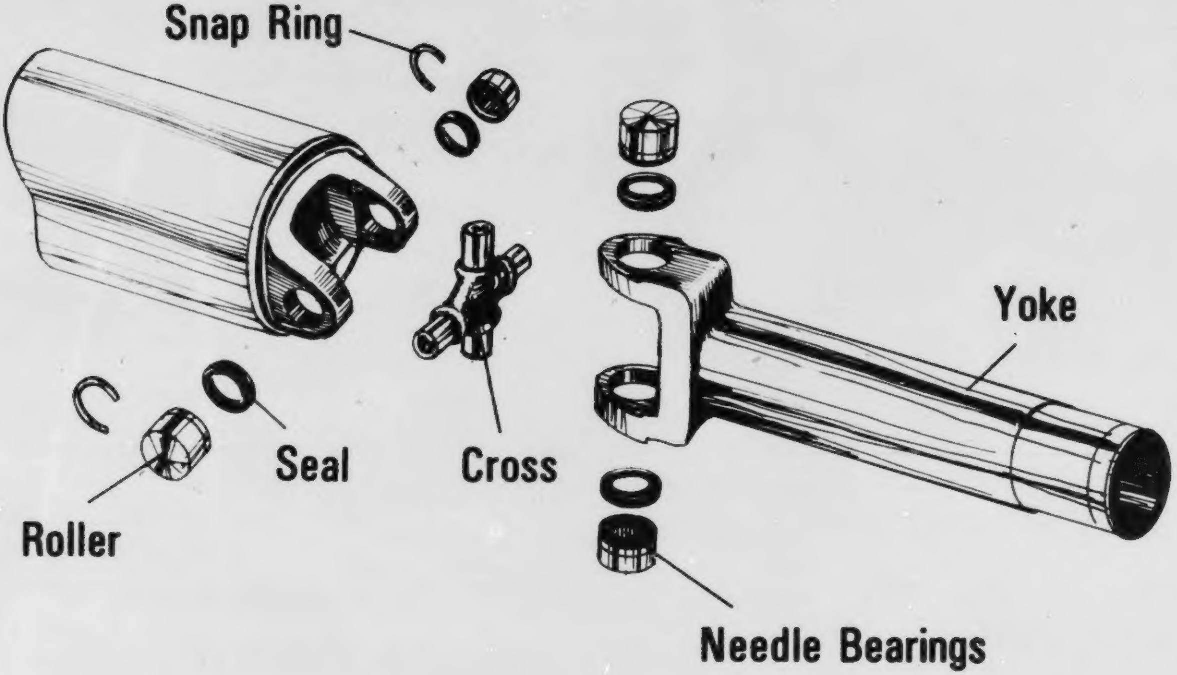


Constant Velocity

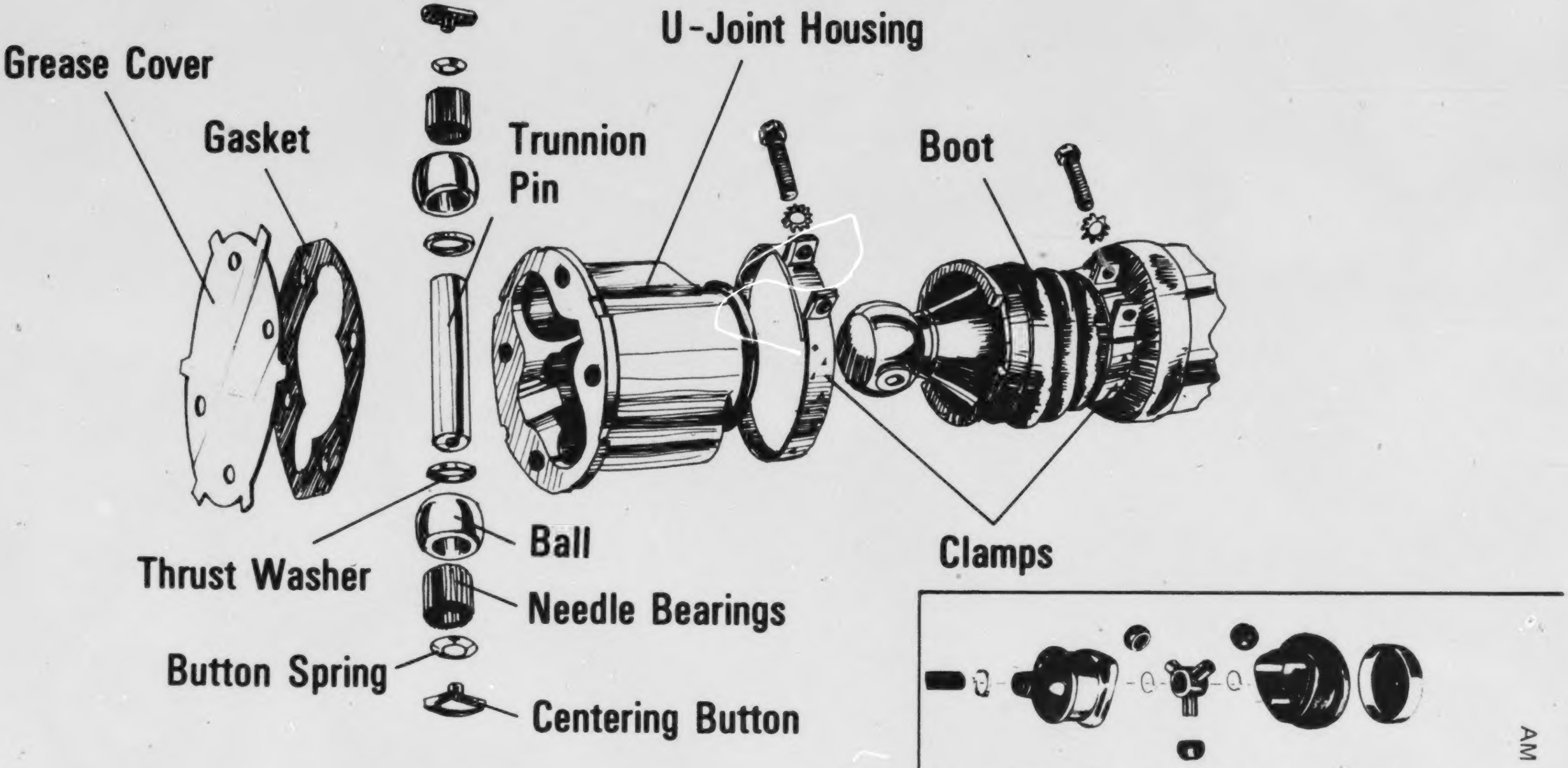


Rzeppa

Cross and Roller U- Joint


Snap Ring
Yoke
Seal
Cross
Roller
Needle Bearings

Ball and Trunnion U-Joint


Grease Cover
Gasket
Trunnion Pin
U-Joint Housing
Boot
Thrust Washer
Ball
Needle Bearings
Button Spring
Centering Button
Clamps

Three-Ball and Trunnion U-Joint

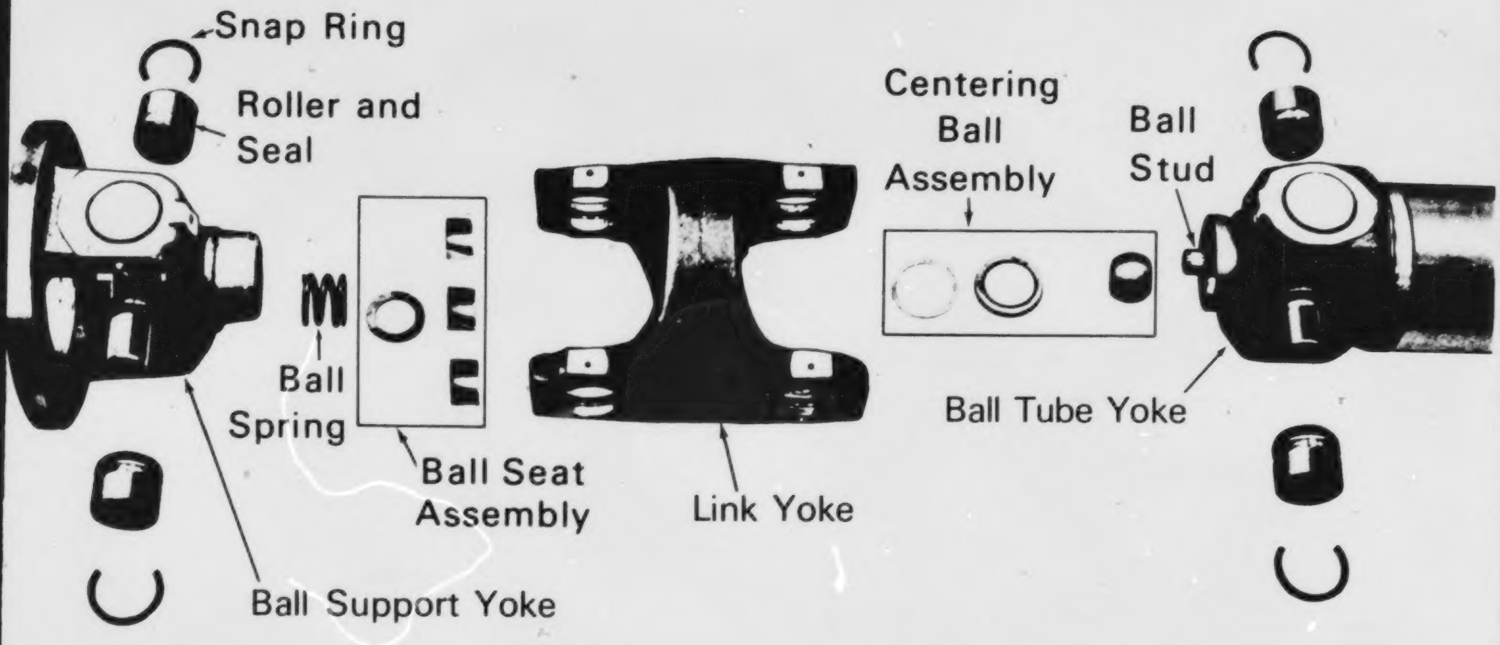
TM 5

724

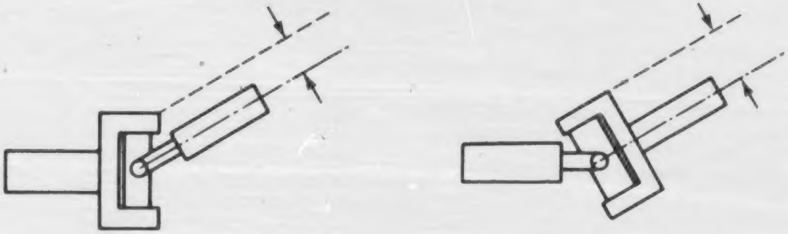
725

AM II - 113-C

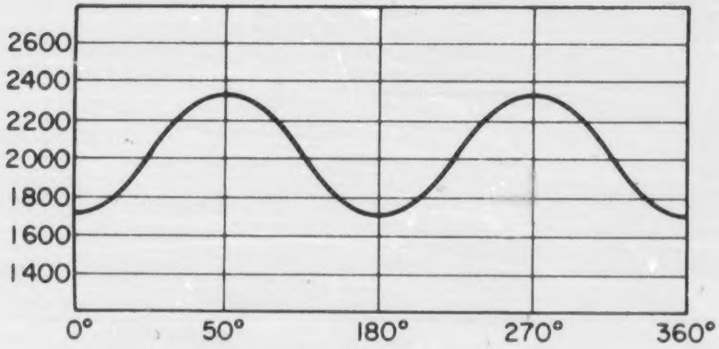
Parts of a Constant Velocity U-Joint


Snap Ring
Roller and Seal
Centering Ball Assembly
Ball Stud
Ball Spring
Ball Seat Assembly
Link Yoke
Ball Tube Yoke
Ball Support Yoke

Acceleration - Deceleration in a Cross and Roller Propeller Shaft

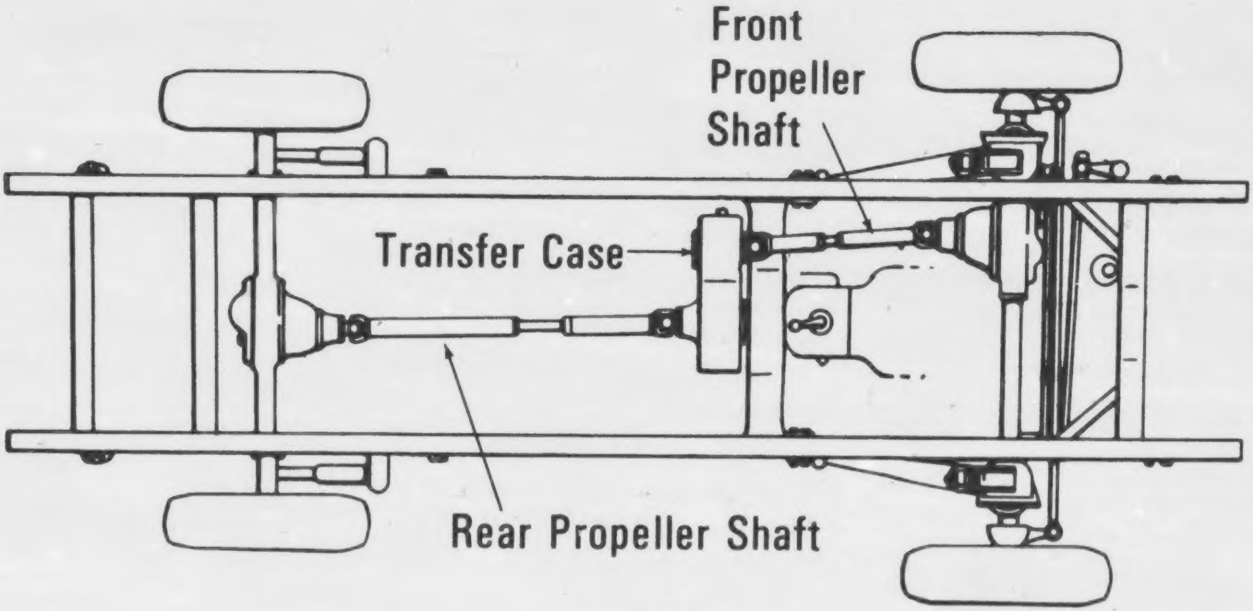


Turning Radius Changes as Joint Rotates

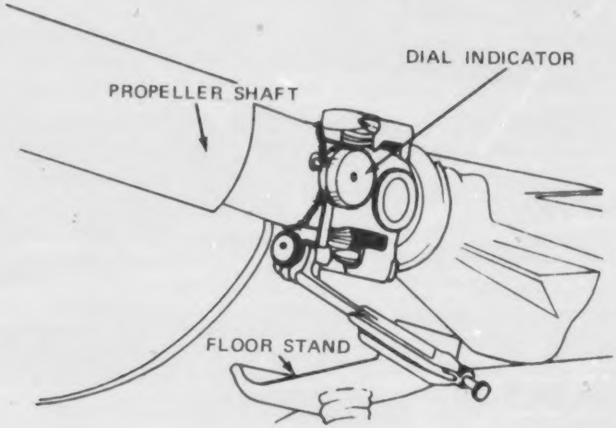


Graph of a Cross and Roller U-Joint Speed Change with the Joint Operating Through a 30° Angle at 2000 rpm Input.

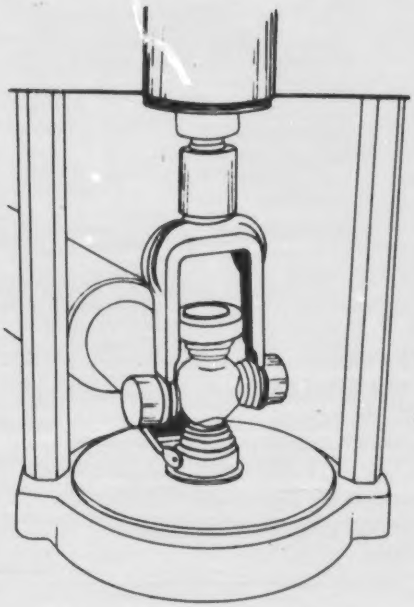
Components of the Drive Line on a Four Wheel Drive Vehicle


Front Propeller Shaft
Transfer Case
Rear Propeller Shaft

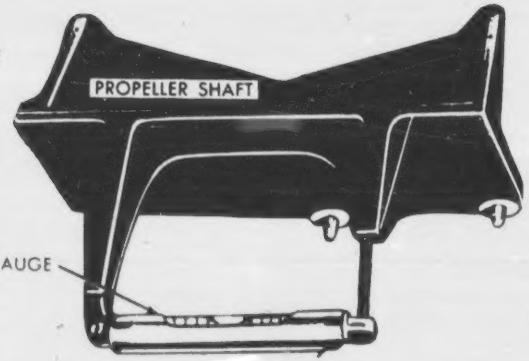
Tools Used for Drive Line Repair


DIAL INDICATOR
PROPELLER SHAFT
FLOOR STAND

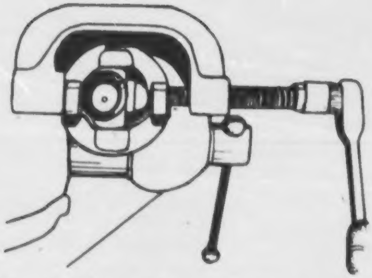
Dial Indicator for Shaft Runout



Hydraulic Press Tool

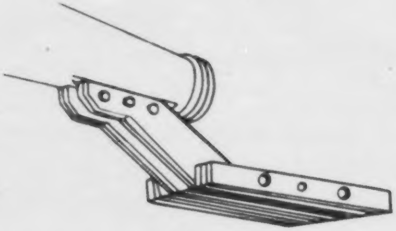

PROPELLER SHAFT
GAUGE

Inclinometer

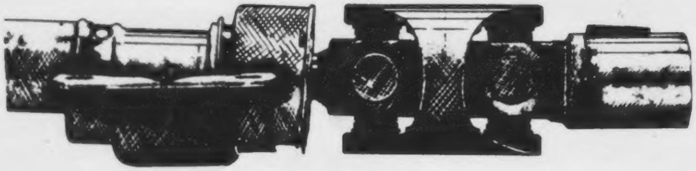


U-Joint Hand Press

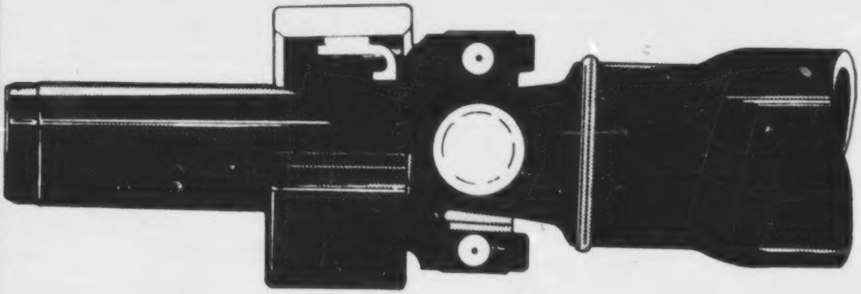
Methods of Controlling Drive Line Vibration



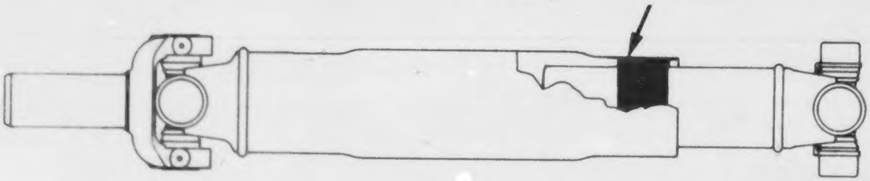
Vibration Absorber



Constant Velocity U-Joint



Torsional Vibration Damper



Elastomer Sleeved
Propeller Shaft

DRIVE LINES
UNIT III

JOB SHEET #1--REMOVE AND REPLACE A PROPELLER SHAFT

I. Tools and equipment

  A. Floor jack

  B. Jack stands

  C. Basic hand tool set

  D. Soft hammer

  E. Torque wrench and adapter

  F. Creeper

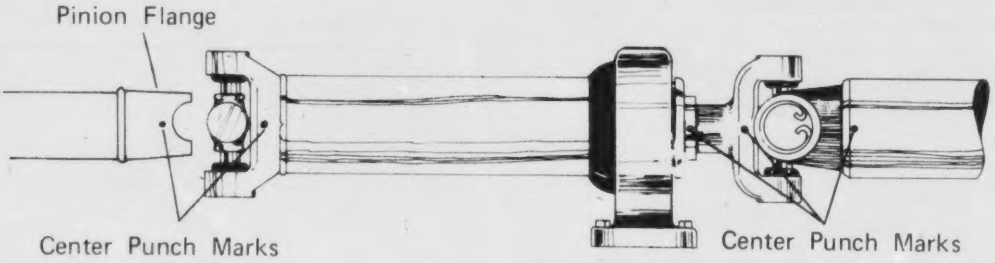
  G. Safety glasses

II. Procedure

  A. Jack up rear of vehicle and place jack stands under frame

  B. Mark all joints and yokes with a center punch to retain balance and phasing (Figure 1)

FIGURE 1



  C. Remove propeller shaft attaching bolts

  (NOTE. Study the propeller shaft to determine how it is fastened.)

  D. Remove the center support bearing if a two-piece propeller shaft is used

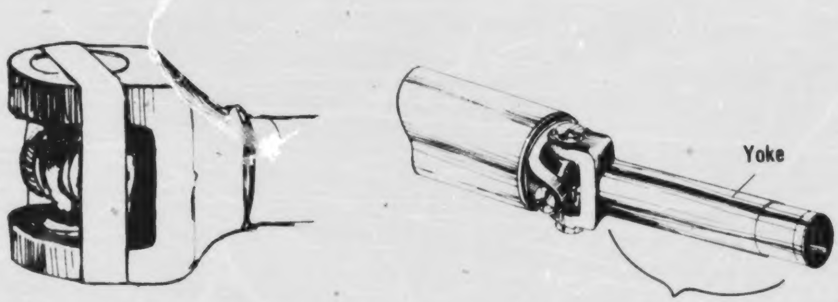
  (NOTE: Check between center support and frame for shims. If shims are used, they must be replaced when propeller shaft is reinstalled.)

JOB SHEET #1

E. Remove propeller shaft from vehicle

(NOTE: Tape U-joint rollers to prevent loss of needle bearings. See Figure 2. The slip yoke should also be protected to prevent damage during removal.)

FIGURE 2



Tape Rollers On

Protect This Area

(CAUTION: When removing, replacing, or servicing a propeller shaft, careless handling can damage the shaft and U-joints.)

F. Service propeller shaft

G. Reinstall propeller shaft

1. Place in position and check alignment marks

   (NOTE: All mounting surfaces should be clean and free of nicks before assembly.)

2. Position all fasteners correctly and tighten evenly

3. Replace fasteners in center support bearing if used

   (NOTE: Replace shims between frame and support if used.)

4. Torque all fasteners to manufacturer's specifications

H. Jack up rear of car and remove jack stands

I. Lower vehicle to floor

DRIVE LINES
UNIT III

JOB SHEET #2--REMOVE AND REPLACE A CROSS AND ROLLER U-JOINT

I. Tools and equipment

A. Basic hand tool set

B. Soft hammer

C. Brass punch

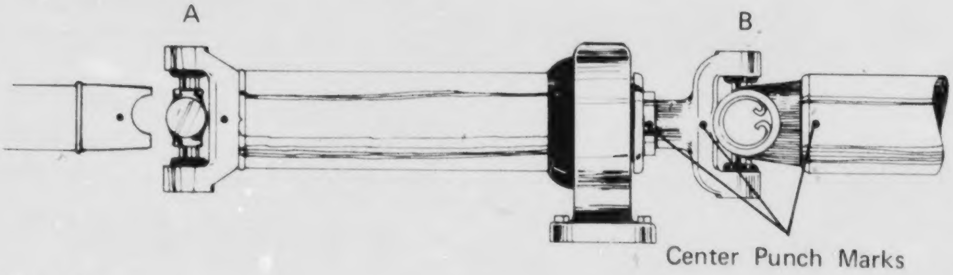
D. Vise

E. Safety glasses

II. Procedure

A. Mark all parts with a center punch so the parts may be reassembled in the same positions (Figure 1)

FIGURE 1



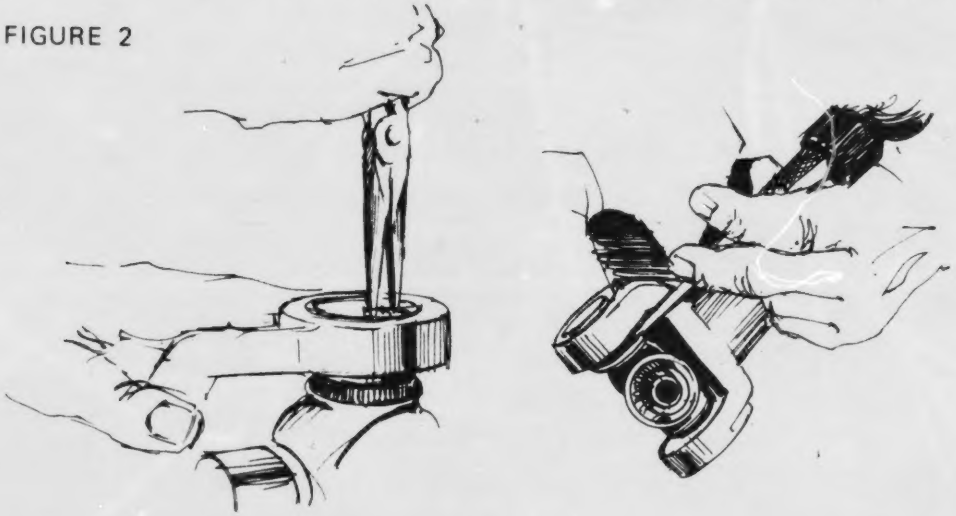
(NOTE: It is very important to align the propeller shaft parts A and B when reassembling the two shafts.)

JOB SHEET #2

B. Remove snap rings or retainer plates and grease fittings as required (Figure 2)

(CAUTION: If the propeller shaft is held in the vise while removing the snap rings, do not bend, overtighten, or scar the shaft with the vise.)

FIGURE 2

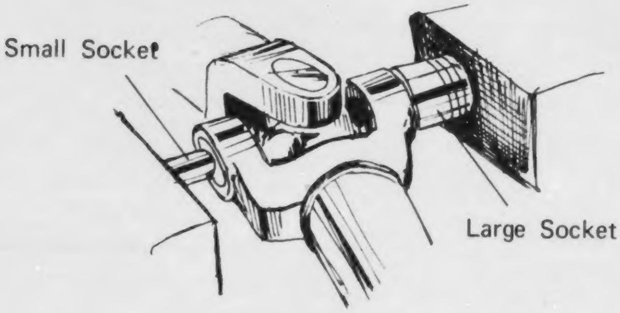


C. Place a small socket against one roller; place a large socket against the yoke on the opposite side (Figure 3)

D. Place in a vise and close the vise jaws until the roller assembly is pressed out of the yoke (Figure 3)

(CAUTION: Be sure the large socket has enough room to allow the roller to enter without wedging in the socket.)

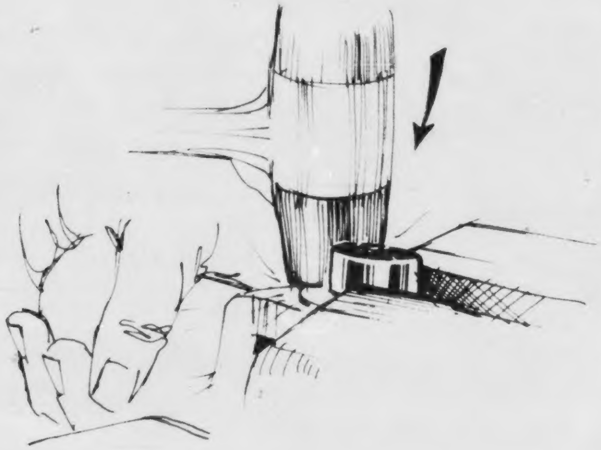
FIGURE 3



JOB SHEET #2

(NOTE: Remove roller with pliers or soft hammer. See Figure 4.)

FIGURE 4



E. Place small socket on remaining roller; place the large socket against the yoke on the opposite side

(NOTE: Use caution to avoid damaging seal shields.)

F. Place in a vise and close the vise jaws until the roller assembly is pressed out of the yoke

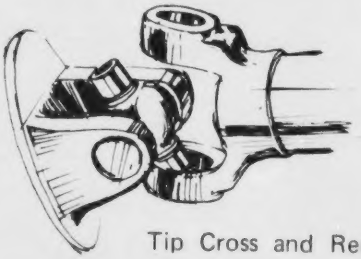
(NOTE: Refer to Figure 3.)

G. Remove roller with pliers or soft hammer

(NOTE: Refer to Figure 4.)

H. Remove the cross from the yoke (Figure 5)

FIGURE 5



Tip Cross and Remove from Yoke

JOB SHEET #2

I. Remove other rollers using the same procedure

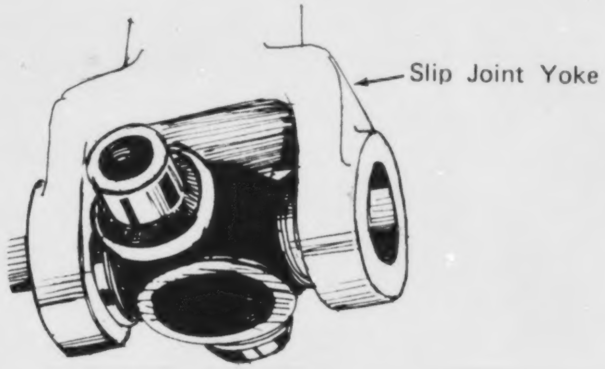
J. Inspect cross trunnions for excessive wear, corrosion, or grooving; check all needle bearings for chipping or breakage

(NOTE: If the components are not worn, they may be correctly lubricated and reused. If there is any sign of wear, install a new U-joint.)

K. Reassemble the U-joint

1. Place the cross in the propeller shaft yoke (Figure 6)

FIGURE 6



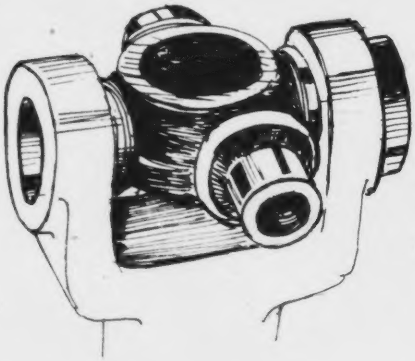
(NOTE On U-joint with grease fittings, the fitting should be positioned on the propeller shaft side to allow clearance for lubrication after installation.)

JOB SHEET #2

2. Slide the cross to one side and start a roller over the cross bearing race (Figure 7)

3. Start the roller in the yoke eye (Figure 7)

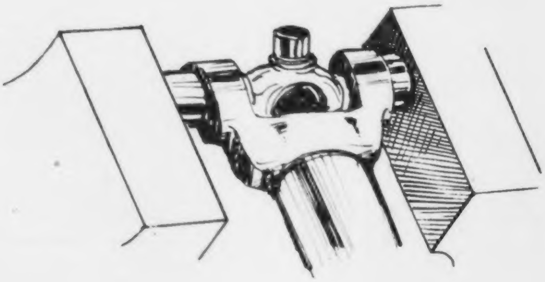
FIGURE 7



4. Place U-joint in a vise and press the roller into the yoke eye (Figure 8)

   (NOTE: Be sure to keep the cross in the roller bearings to prevent the bearings from loosening or getting out of their proper position.)

FIGURE 8

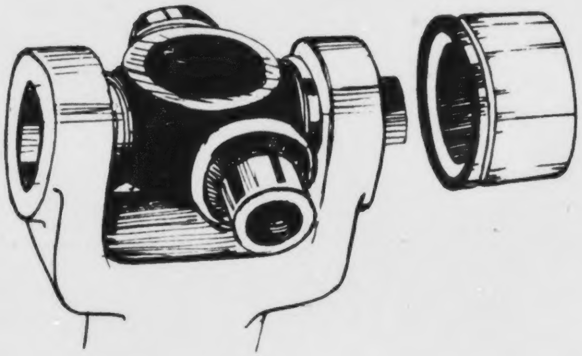


JOB SHEET #2

5. Install the snap ring into the roller groove or yoke eye groove according to the type of U-joint

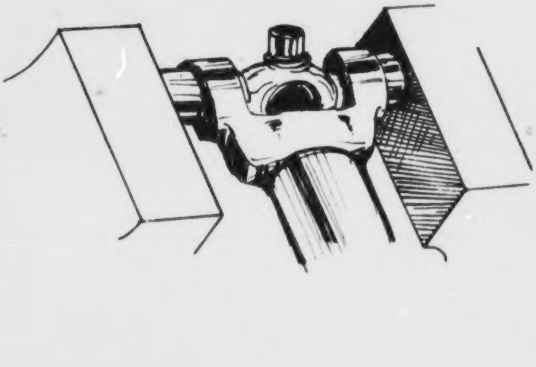
6. Slide the cross slightly out of the roller so that the opposite roller can be started on the cross bearing race (Figure 9)

FIGURE 9



7. Place in a vise and press the roller into the yoke eye sufficiently to install the snap ring (Figure 10)

FIGURE 10



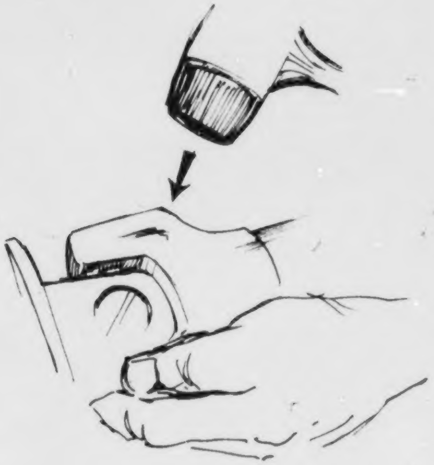
JOB SHEET #2

8. Replace remaining U-joint rollers using the same procedure; install remaining snap rings

9. Strike yoke to seat rollers against the snap rings and to position the cross (Figure 11)

   (NOTE: Make sure the U-joint is not binding throughout its range of movement.)

FIGURE 11



DRIVE LINES
UNIT III

JOB SHEET #3--REMOVE AND REPLACE A BALL AND TRUNNION U-JOINT

I. Tools and equipment

- A. Safety glasses
- B. Screwdriver
- C. Punch
- D. Arbor press and vise
- E. Steel rule

II. Procedure

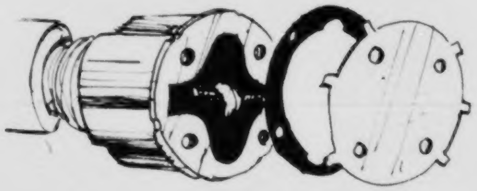
A. Secure propeller shaft in the vise

(NOTE: Clamp propeller shaft in the vise carefully to avoid damage to shaft.)

B. Straighten the tabs which fasten the sheet metal cover to the U-joint housing

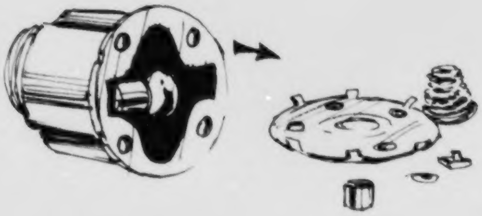
C. Remove sheet metal cover and gasket (Figure 1)

FIGURE 1



D. Push the U-joint housing back to expose the trunnion pin; remove the thrust button, spring, ball, rollers, and thrust washer from each end of pin (Figure 2)

FIGURE 2



JOB SHEET #3

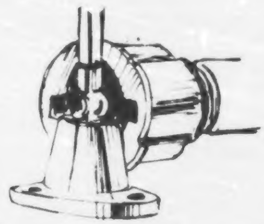
E. Remove the clamps and loosen the rubber dust cover

F. Clean and examine trunnion pin and raceways in the U-joint housing

(NOTE: If the components are not worn, they can be lubricated and reused. If they show any signs of wear, they should be replaced.)

G. Press out the trunnion pin if replacement is necessary (Figure 3)

FIGURE 3



H. Remove U-joint housing

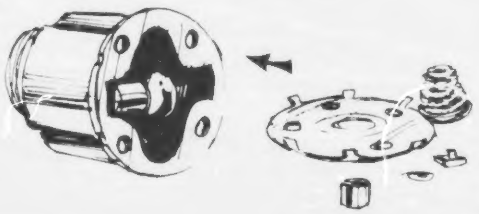
I. Remove rubber dust cover

J. Reassemble U-joint

1. Place rubber dust cover, clamps, and U-joint housing on propeller shaft
2. Start and press trunnion pin through the end of the propeller shaft

   (NOTE: Make sure the trunnion pin is exactly centered.)
3. Install thrust washers, balls, rollers, spring, and thrust buttons on each end of the trunnion pin (Figure 4)

FIGURE 4



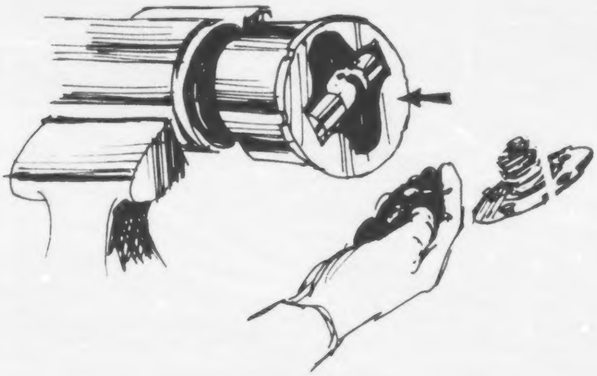
JOB SHEET #3

4. Position U-joint housing over trunnion pin assembly

5. Position rubber dust cover and tighten clamps

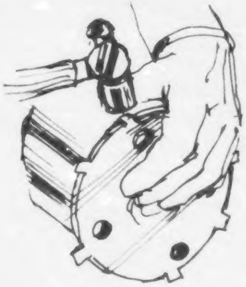
6. Lubricate balls, rollers, and raceways (Figure 5)

FIGURE 5



7. Install sheet metal cover and gasket on propeller shaft housing and bend holding tabs (Figure 6)

FIGURE 6



DRIVE LINES
UNIT III

JOB SHEET #4--BALANCE A PROPELLER SHAFT

I. Tools and equipment

A. Hose clamps (slightly larger than propeller shaft)

B. Chalk, crayon, or pencil

C. Jack stands, 5

D. Floor jack

(NOTE: Use a twin-post hoist if available.)

E. Basic hand tool set

F. Safety glasses

II. Procedure

(NOTE: If a balance problem exists, the propeller shaft should be cleaned of build-up of foreign materials and checked to determine if any balance weights have been lost and that the shaft is properly installed. Road test after cleaning. If the problem still exists, disconnect the propeller shaft from the pinion and rotate 180 degrees. Reconnect propeller shaft and road test again. If the problem still exists, balance the propeller shaft using the following procedure.)

A. Place the vehicle on jack stands so that the rear of the vehicle is supported on the rear axle housing with the wheels free to rotate

B. Set a jack stand approximately 1 inch (25.4 mm) from the propeller shaft (Figure 1)

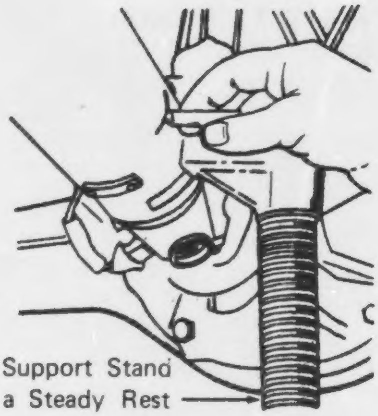
C. Start the engine and rotate the propeller shaft at 40-50 mph (65-80 km/h)

D. Mark the propeller shaft by carefully bringing the crayon or pencil up until it just barely contacts the rear end of the spinning propeller shaft (Figure 1)

(CAUTION: Avoid contact with the spinning shaft and tires. While marking the shaft, avoid areas where balance weights are located because they could injure your hands.)

JOB SHEET #4

FIGURE 1

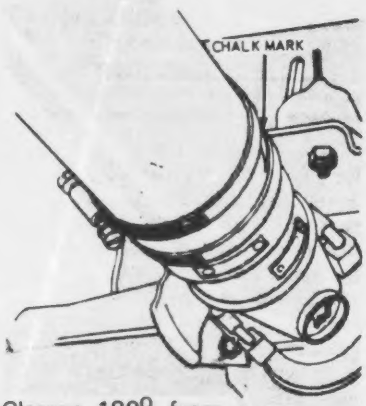

Use Support Stand as a Steady Rest

(NOTE: The mark made by the crayon or pencil will indicate the heavy side of the shaft.)

E. Turn off the engine

F. Install two screw type hose clamps on the rear of the propeller shaft so that the screw heads are 180 degrees from the mark on the propeller shaft (Figure 2)

FIGURE 2



Clamps 180° from Chalk Mark

JOB SHEET #4

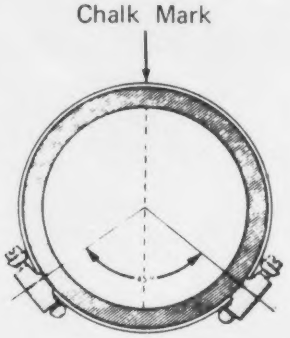
G. Tighten clamps securely

H. Run the vehicle up to 65-70 mph (104-112 km/h) speedometer reading

(NOTE: If no vibration is felt, road test the vehicle as a final test. If vibration still exists, proceed as follows.)

I. Rotate the clamp heads approximately 45 degrees from each other and retest (Figure 3)

FIGURE 3



J. Continue to rotate the clamp heads apart in smaller amounts until vibration is eliminated

DRIVE LINES
UNIT III

JOB SHEET #5--CHECK AND ADJUST U-JOINT ANGLES

I. Tools and equipment

   A. Basic hand tool set

   B. Safety glasses

   C. Inclinometer (angle gauge)

   D. Jack stands

   E. Floor jack

   F. Assortment of shims

   G. Transmission jack

II. Procedure

   A. Support vehicle on jack stands or hoist so that the vehicle is supported on the rear axle housing in normal operating position

   (NOTE: Specifications are usually listed for an approximately level empty vehicle with a full gas tank.)

   B. Mount the inclinometer at the rear U-joint according to manufacturer's directions

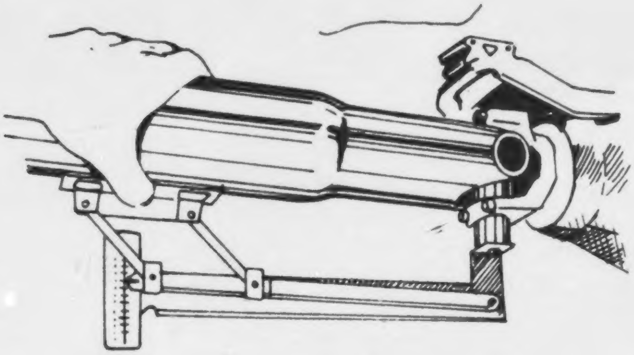
   (NOTE: The figures shown are of one particular gauge; applications will vary from gauge to gauge.)

JOB SHEET #5

C. Take U-joint angle reading (Figure 1)

(NOTE: Make sure that the gauge is set on clean areas of the shaft. Calibration of the inclinometer can be performed by attaching to any level surface and adjusting the gauge to zero.)

FIGURE 1



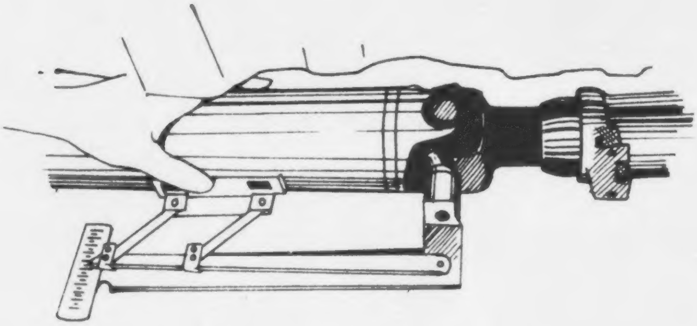
Measuring U-Joint Angle at Axle

D. Compare gauge reading to specifications to determine amount of correction needed

E. Mount inclinometer at front of propeller shaft and front U-joint (Figure 2)

F. Take U-joint angle reading (Figure 2)

FIGURE 2



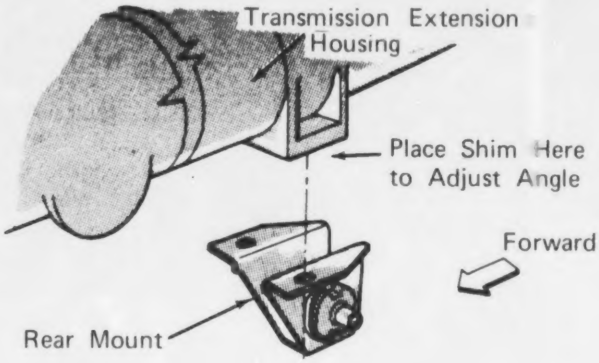
Measuring U-Joint Angle at Transmission

JOB SHEET #5

G. Correct front U-joint angle

(NOTE: For two piece propeller shafts, adjusting the shim pack at the center support bearing will change both front and rear angles. If angle reads low or negative, no correction is required. To reduce large angles, place shims between extension housing and engine rear mount See Figure 3.)

FIGURE 3


Transmission Extension Housing
Place Shim Here to Adjust Angle
Forward
Rear Mount

Shim Location (Front U-Joint Angle Correction)

1. Remove engine rear mount bolts at extension housing
2. Raise transmission with transmission jack enough to install shims

   (NOTE. Usually a 1/8" [3.175 mm] shim will reduce the angle approximately 1/4 degree.)
3. Install correct amount of shims
4. Lower transmission
5. Install bolts and tighten to specified torque
6. Remeasure angle to check results of the adjustment

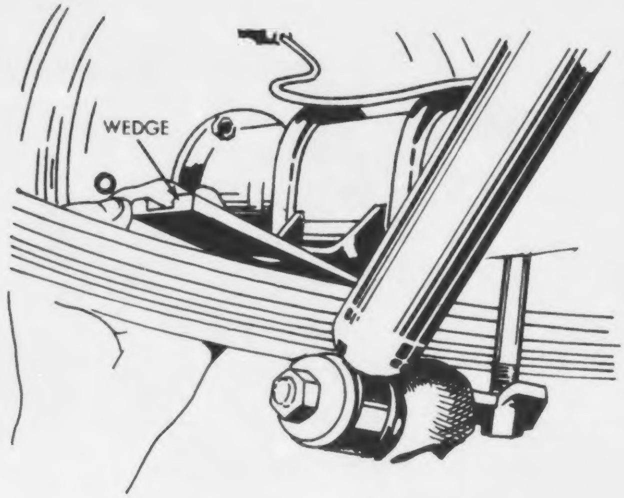
JOB SHEET #5

H. Correct rear U-joint angle

(NOTE: If correction is necessary, tapered wedge type shims in values of 1 to 4 degrees are available for the rear axle with leaf type springs. On trailing arm suspension, shims will be used between the upper control arm and frame.)

1. Loosen spring U-bolt nuts enough to install shims between spring and spring seat (Figure 4)

FIGURE 4



Tapered Wedge Location
(Rear U-Joint Angle Correction)

2. Install shims

   (NOTE: Installing the thick end of shim towards the front of the vehicle reduces the angle. Installing it towards the rear of the vehicle increases the angle.)

3. Tighten U-bolt nuts to proper torque

4. Remeasure U-joint angle to check results of adjustment

   (NOTE: Do not shim more than one-fourth inch [6.35 mm] measured at the center of the shim. If more correction is indicated, look for possible broken spring, mislocated spring seat, or other suspension wear or damage.)

DRIVE LINES
UNIT III

TEST

NAME ______________________________ SCORE ____________________

1. Match the terms on the right to the correct definitions.

_____a. Driving connection made up of one or more propeller shafts between transmission and differential

_____b. Coupling that allows power to be transferred through an angle

_____c. Variable-length connection at one end of a propeller shaft that allows the shaft to vary in length as the vehicle body moves up and down in relation to the rear axle

_____d. Cross and roller U-joint

_____e. Propeller shaft runout or unbalanced condition causing the shaft to act similar to the looping action of a rope held at both ends and swung in an arc

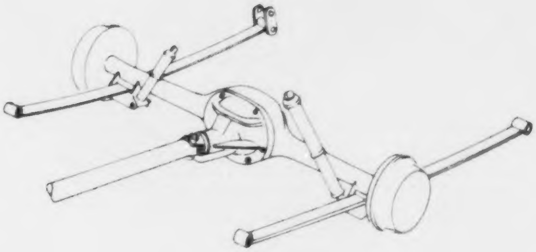
_____f. Two closely coupled cross and roller U-joints arranged so that their acceleration-deceleration effects cancel each other, resulting in output propeller shaft speed identical to input speed

_____g. Shaft that connects the transmission to the rear axle to propel the vehicle

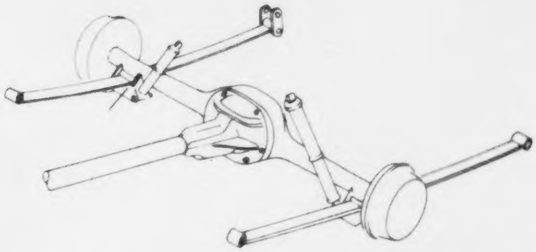
_____h. Procedure of aligning the yokes of a two or more piece propeller shaft to help control whirl and vibration in the propeller shaft

1. Whirl
2. Propeller shaft
3. Cardan joint
4. U-joint
5. Constant velocity U-joint
6. Drive line
7. Slip joint
8. U-joint timing

2. Identify the following types of drive lines.



a. ____________________



b. ____________________

3. Identify the components of the propeller shaft below by writing the correct names in the blanks provided.

a. ____________

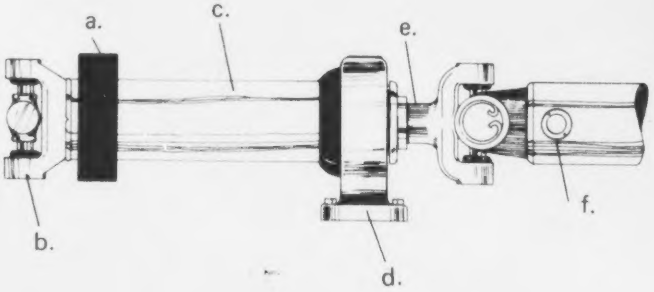
b. ____________

c. ____________

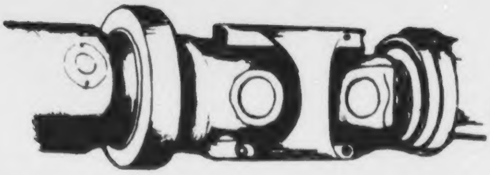
d. ____________

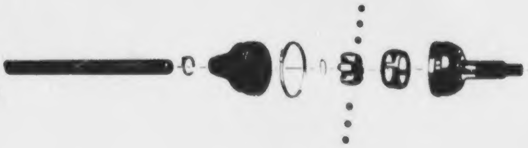
e. ____________

f. ____________

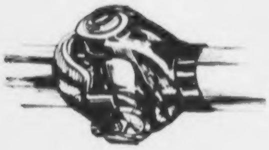


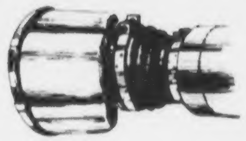
4. Identify the following types of U-joints by writing the correct names in the blanks.





a. ______________________ b. ______________________





c. ______________________ d. ______________________

5. Identify the parts of the cross and roller U-joint below by placing the number of the part in the blank next to the correct name.

______a. Yoke

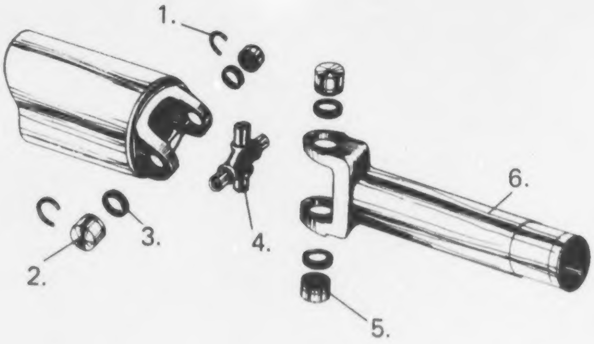
______b. Needle bearings

______c. Cross

______d. Seal

______e. Snap ring

______f. Roller



6. Identify the parts of the ball and trunnion U-joint below by placing the part number in the blank next to the correct name.

_____a. Centering button

_____b. Needle bearings

_____c. Boot

_____d. U-joint housing

_____e. Trunnion pin

_____f. Gasket

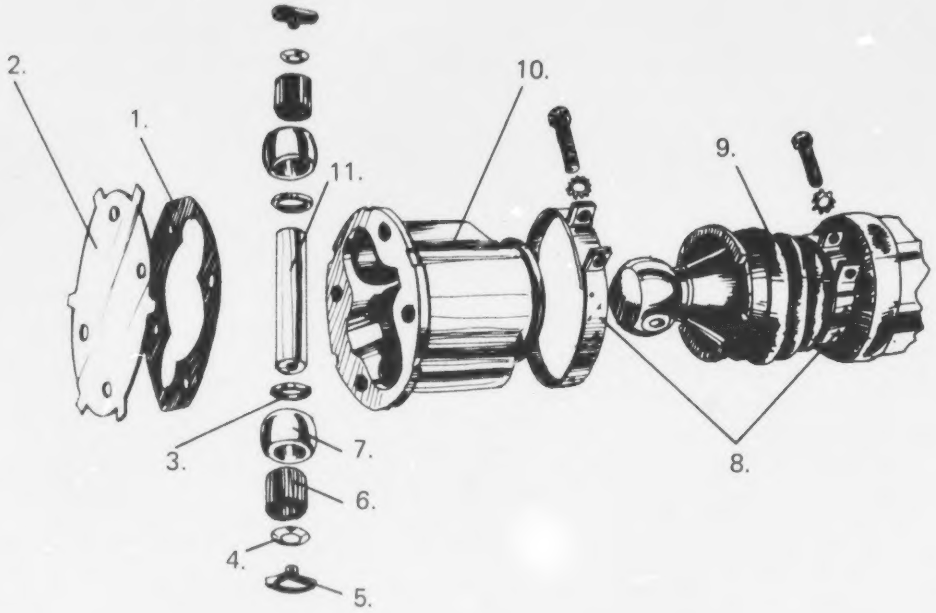
_____g. Button spring

_____h. Grease cover

_____i. Thrust washer

_____j. Ball

_____k. Clamps



7. Identify the parts of the constant velocity U-joint below by placing the part number in the blank next to the correct name.

_____a. Ball stud

_____b. Link yoke

_____c. Ball support yoke

_____d. Ball spring

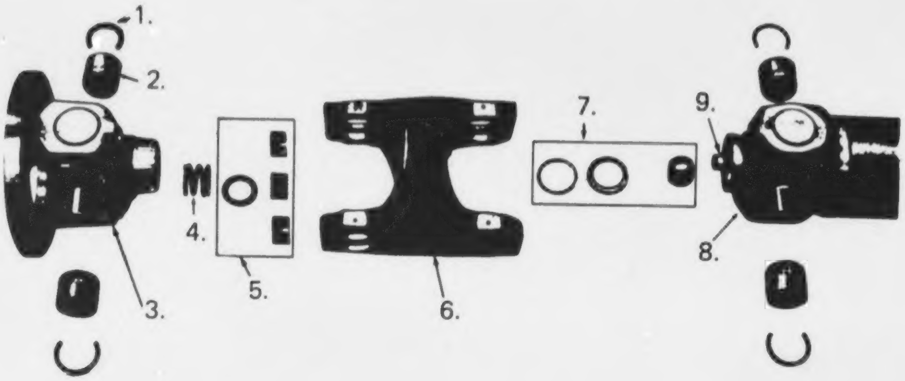
_____e. Ball seat assembly

_____f. Snap ring

_____g. Ball tube yoke

_____h. Centering ball assembly

_____i. Roller and seal



8. Discuss the acceleration-deceleration of a propeller shaft equipped with cross and roller U-joint.

____

____

____

____

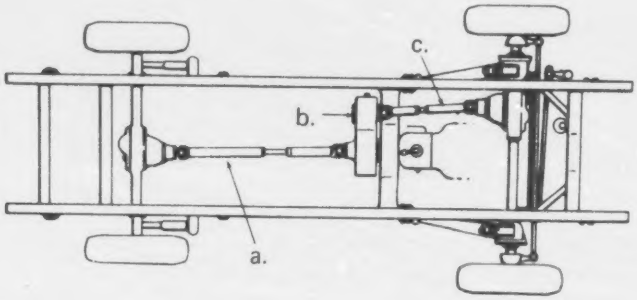
____

9. Identify the major components of a four wheel drive.

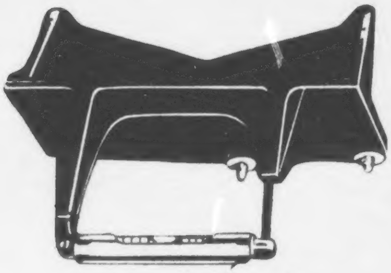
a. ____________

b. ____________

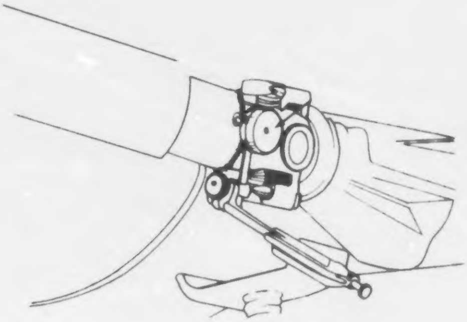
c. ____________



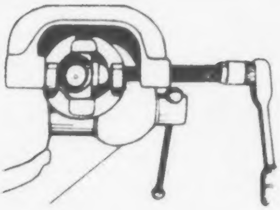
10. Identify the following tools used in drive line repair.



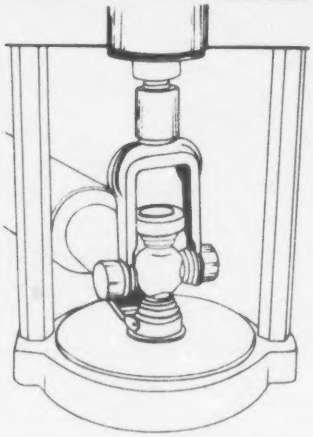
a. ____________________



b. ____________________



c. ____________________



d. ____________________

11. List four methods of controlling drive line vibration.

    a. ______________________________

    b. ______________________________

    c. ______________________________

    d. ______________________________

12. Demonstrate the ability to:

    a. Remove and replace a propeller shaft.

    b. Remove and replace a cross and roller U-joint.

    c. Remove and replace a ball and trunnion U-joint.

    d. Balance a propeller shaft.

    e. Check and adjust U-joint angles.

    (NOTE If these have not been accomplished prior to the test, ask the instructor when the above activities should be completed.)

DRIVE LINES
UNIT III

ANSWERS TO TEST

1. a. 6
    b. 4
    c. 7
    d. 3
    e. 1
    f. 5
    g. 2
    h. 8
2. a. Hotchkiss drive
    b. Torque-tube drive
3. a. Torsional damper
    b. U-joint
    c. Shaft
    d. Center bearing support (carrier bearing)
    e. Slip joint
    f. Balance weight
4. a. Constant velocity
    b. Rzeppa
    c. Cross and roller
    d. Ball and trunnion
5. a. 6
    b. 5
    c. 4
    d. 3
    e. 1
    f. 2

6. a. 5
   b. 6
   c. 9
   d. 10
   e. 11
   f. 1
   g. 4
   h. 2
   i. 3
   j. 7
   k. 8

7. a. 9
   b. 6
   c. 3
   d. 4
   e. 5
   f. 1
   g. 8
   h. 7
   i. 2

8. Discussion should include:
   a. Input side of joint turns at constant speed
   b. Output side of the joint accelerates and decelerates twice during one revolution of the shaft
   c. The greater the U-joint running angle is, the greater the effect will be

9. a. Rear propeller shaft
   b. Transfer case
   c. Front propeller shaft

10. a. Inclinometer
    b. Dial indicator
    c. U-joint hand press
    d. Hydraulic press tool

11. a. Elastomer sleeved propeller shaft
    b. Torsional vibration damper
    c. Constant velocity U-joint
    d. Vibration absorber

12. Performance skills evaluated to the satisfaction of the instructor.

REAR AXLE
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify the components of the rear axle assembly and discuss its purposes. The student should be able to remove, repair, and replace the rear axle assembly. This knowledge will be evidenced through demonstration and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Discuss in writing the purposes of the rear axle assembly.
2. Match terms associated with the rear axle to the correct definitions.
3. Identify parts of a gear tooth.
4. Identify the parts of a conventional differential.
5. Identify the parts of a planetary differential.
6. Identify two types of differential carrier housings.
7. Discuss the ideal ring gear and drive pinion tooth contact pattern.
8. Match the types of ring gear tooth contact patterns with the correct diagrams.
9. Identify the types of rear axle shafts.
10. List three types of rear axle bearings.
11. Demonstrate the ability to:
    a. Measure the backlash between a ring gear and drive pinion gear.
    b. Test the ring gear and drive pinion gear tooth contact pattern.
    c. Replace a drive pinion seal.
    d. Replace a ball bearing type rear axle shaft bearing and seal.

e. Adjust the drive pinion bearing preload with carrier assembly removed.

f. Select pinion depth spacer with a pinion depth gauge.

g. Adjust backlash and carrier bearing preload.

h. Remove and replace a rear axle housing assembly.

i. Disassemble, inspect, reassemble, and adjust an integral carrier rear axle.

REAR AXLE
UNIT IV

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss procedures outlined on the job sheets.

   G. Give test.

II. Unit references:

   A. Stockel, Martin W. *Auto Service and Repair.* Homewood, Illinois: Goodheart-Willcox Co., 1969.

   B. Toboldt, William K., and Johnson, Larry. *Motor Service's Automotive Encyclopedia.* South Holland, Illinois: Goodheart-Willcox Co., 1970.

   C. *Chevrolet Service Manual.* Detroit, Michigan: Chevrolet Motor Division, General Motors Corp., 1973.

   D. *Plymouth Service Manual.* Detroit Michigan: Chrysler-Plymouth Division, Chrysler Corp., 1967.

   E. "Car and Light Truck Axles: Overhaul and Major Repair." Ford Service Training Course 4002.1. Dearborn, Michigan: Ford Motor Co., 1968.

REAR AXLE
UNIT IV

INFORMATION SHEET

I. Purposes of the rear axle assembly

   A. To change the direction of power flow

   B. To provide a means by which the vehicle can corner without the rear wheels skidding

II. Terms and definitions

   A. Hypoid gearing--Set of gears in which the drive pinion gear is below the center line of the ring gear (Transparency 1)

   B. Differential--Unit that will drive both rear wheels at the same time but will allow them to turn at different speeds when negotiating turns

   C. Backlash--Distance that one gear can be moved back and forth without moving the gear into which it is meshed (Transparency 2)

   D. Gear tooth clearance--Distance separating two gear teeth that are meshed together (Transparency 2)

   E. Preload--Adjustment of antifriction bearings so that they are under mild pressure; tested by the amount of torque in inch pounds required to turn the shaft

   F. Tooth contact pattern test--Method used to test the wiping action between the ring gear and drive pinion gear teeth to determine if they are properly adjusted

   G. Nonslip differential--Special traction differential that automatically transfers torque to the wheel that is not slipping when loss of drive force occurs in the other wheel (Transparencies 3 and 4)

   (NOTE: Rear axle service in the nonslip differential is similar to the conventional units with exception of the clutch units.)

   H. Pattern paste--Solution that indicates the area of contact between gear teeth; can be made of red lead and motor oil, white lead, or Prussian blue

   I. Nonhunting gears--Set of gears in which any one drive pinion gear tooth contacts only a certain number of ring gear teeth; set with timing marks on the gear teeth

INFORMATION SHEET

J. Semifloating axle--Axle supports, retains, and drives the wheel; outer end of axle is supported by a bearing in the axle housing (Transparency 10)

K. Three-quarter floating axle--Axle retains and drives the wheel; load is supported by means of a hub and bearing assembly on the axle housing (Transparency 10)

L. Full-floating axle--Axle drives the wheel; wheel is supported and retained by a hub containing two roller bearings which are attached to the axle housing

(NOTE: Inner ends of all types of axles are supported by the differential.)

III. Parts of a gear tooth (Transparency 2)

A. Toe

B. Heel

C. Pitch line

D. Face

E. Flank

F. Clearance

G. Backlash

IV. Parts of a conventional differential (Transparency 5)

A. Carrier bearings

B. Pinion shaft

C. Side gear

D. Side gear thrust washer

E. Case cover

F. Pinion gear

G. Pinion gear thrust washer

H. Drive pinion gear

I. Differential case

J. Ring gear

INFORMATION SHEET

V. Parts of the planetary differential (Transparency 6)

  A. Drive pinion gear

  B. Ring gear

  C. Internal gear and differential case

  D. Planet carrier

  E. Case cover

  F. Side bearings

  G. Sun gear thrust washer

  H. Planet pinion gears

  (NOTE: There are three inner and three outer gears.)

  I. Sun gear

  J. Axle retainer washer

VI. Types of differential carrier housings

  A. Removable carrier (Transparency 7)

  (NOTE: The differential carrier detaches from the rear axle housing in order for major repairs to be made. It is sometimes called a third member.)

  B. Integral carrier (Transparency 8)

  (NOTE: The differential carrier and rear axle housing are manufactured as one unit with a rear inspection cover through which repairs are made.)

VII. Ring gear and drive pinion tooth contact pattern (Transparency 9)

(NOTE: There is no exact pattern that must be formed; the pattern varies slightly depending on gear wear, load, and design.)

  A. On drive side of tooth (convex side)

    1. Should be centrally located between the top and bottom

    2. Can be slightly closer to the toe end

    3. Tends to spread toward the heel of the tooth as the load increases

INFORMATION SHEET

B. On coast side of the tooth (concave side)

1. Should be centrally located between the top and bottom

2. May be a little longer and slightly closer to the toe end

VIII. Gear tooth contact patterns (Transparency 9)

A. Ideal tooth contact

B. High tooth contact

C. Low tooth contact

D. Toe contact

E. Heel contact

IX. Types of rear axle shafts (Transparency 10)

A. Semifloating

B. Three-quarter floating

C. Full-floating

X. Types of rear axle bearings (Transparency 11)

A. Ball bearing

(NOTE: This bearing is sealed and prelubricated; do not wash in solvent.)

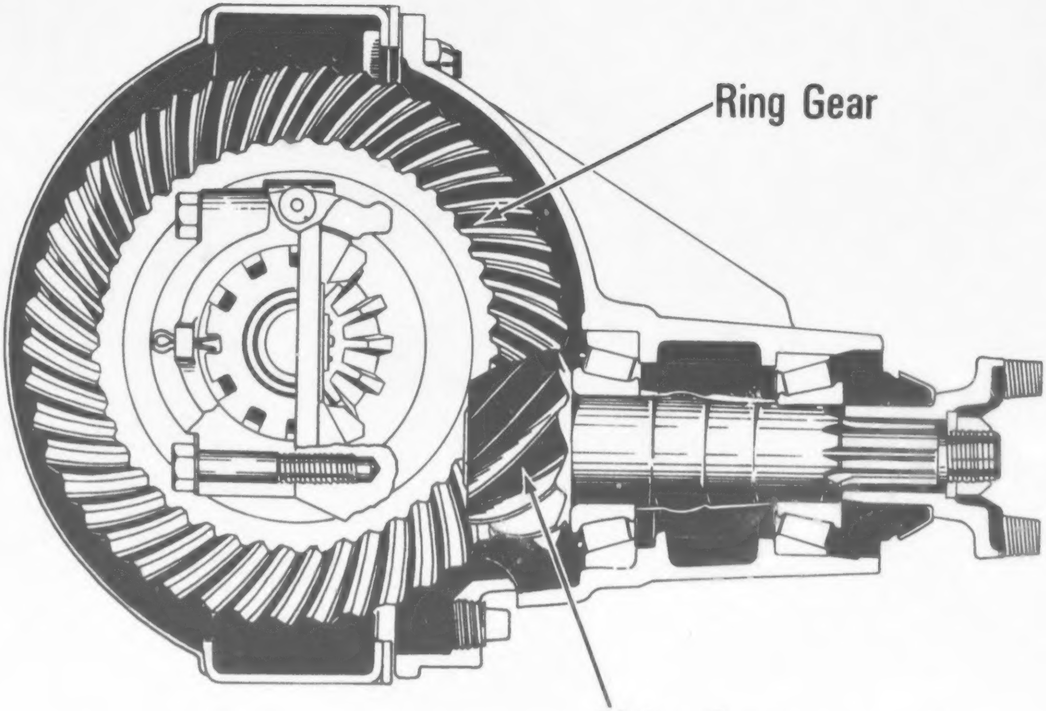
B. Tapered roller bearing

(NOTE: This bearing must be packed with lubricant during installation.)

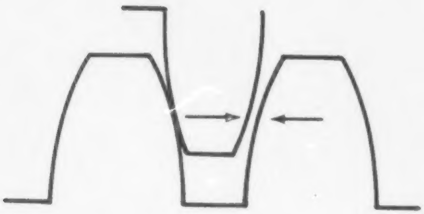
C. Flat roller bearing

(NOTE: This bearing lubricates from the differential.)

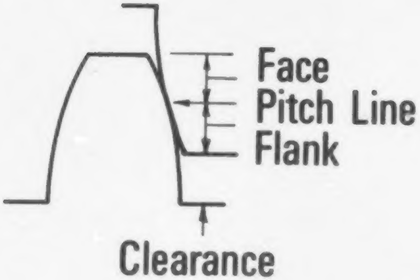
Hypoid Gear Design

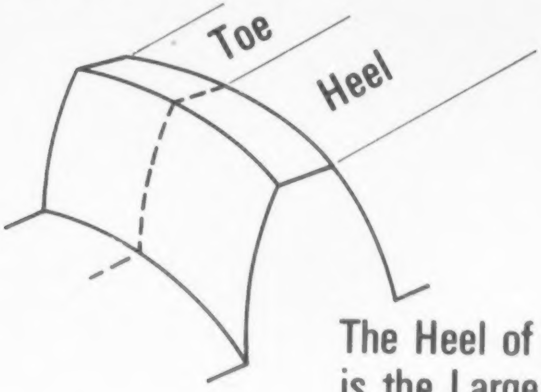

Ring Gear
Pinion Gear

Gear Tooth Nomenclature



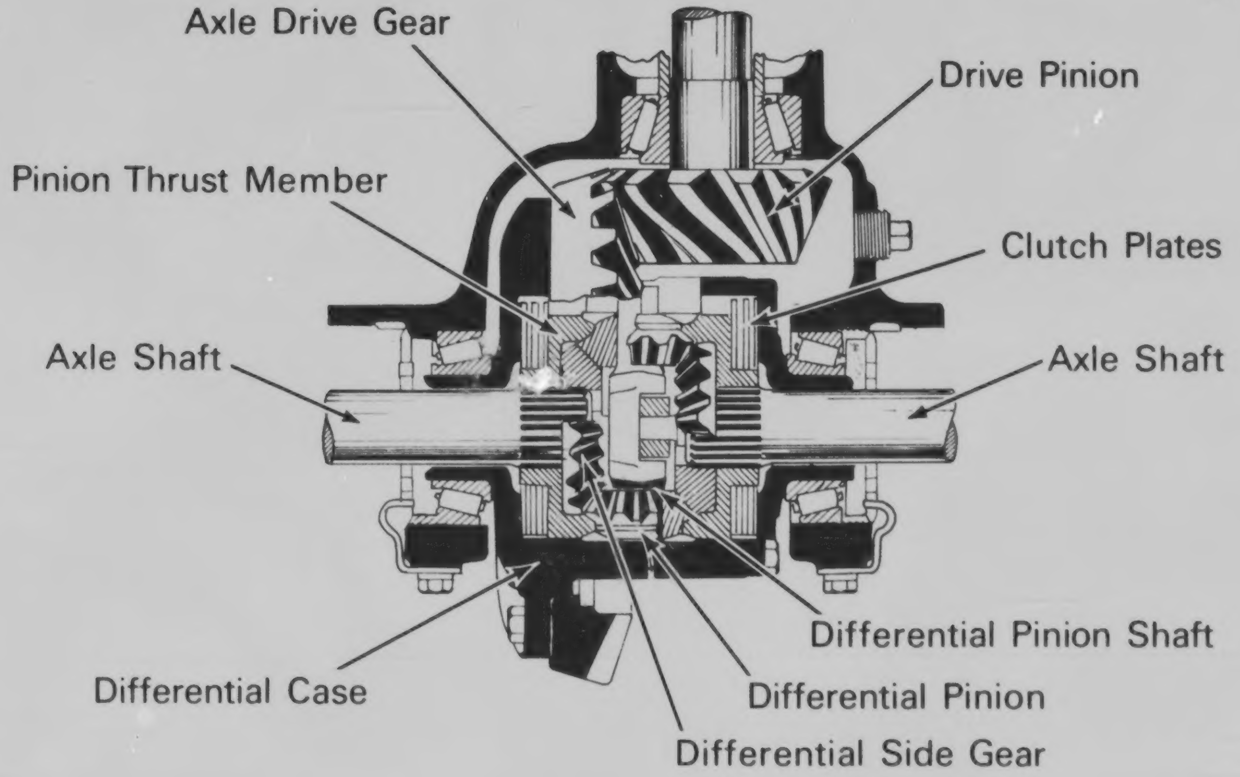
Backlash .005"-.008"
(0.1270-0.2032mm)


Face
Pitch Line
Flank
Clearance



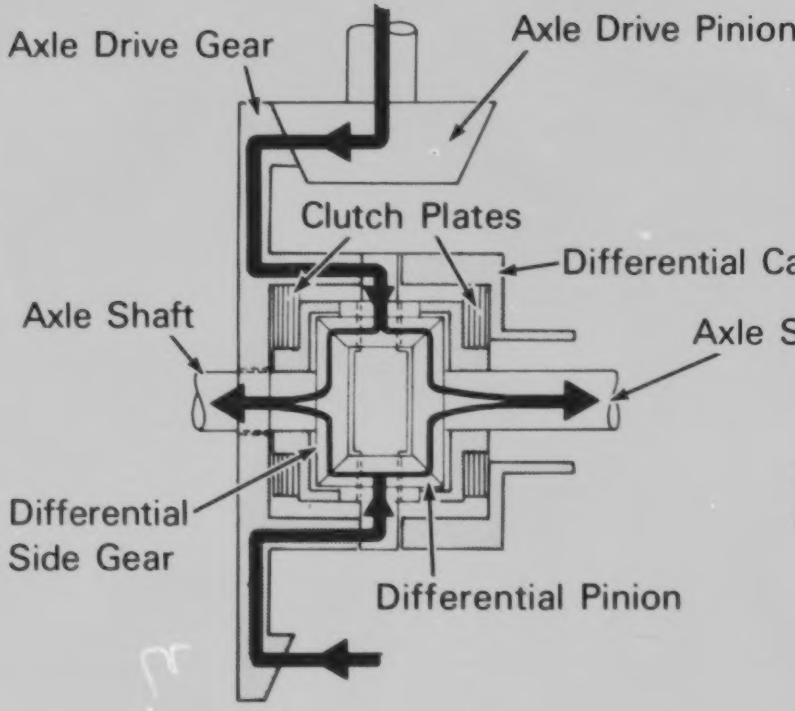
The Heel of the Gear Tooth is the Large End and the Toe is the Small End

Typical Nonslip Differential

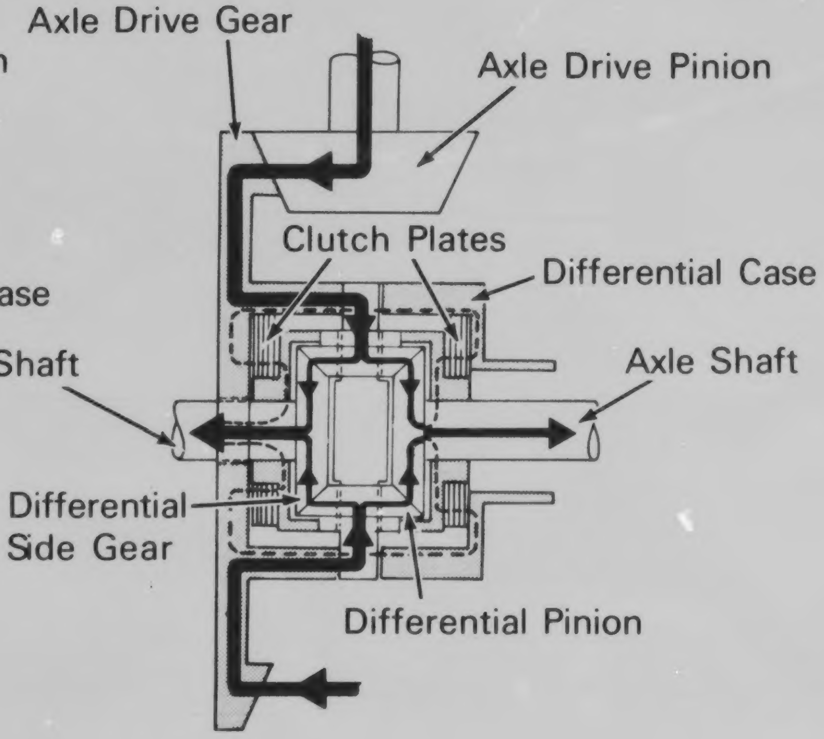

Axle Drive Gear
Drive Pinion
Pinion Thrust Member
Clutch Plates
Axle Shaft
Axle Shaft
Differential Pinion Shaft
Differential Case
Differential Pinion
Differential Side Gear

Nonslip Differential (Cross Section View)

Typical Nonslip Differential
(Continued)

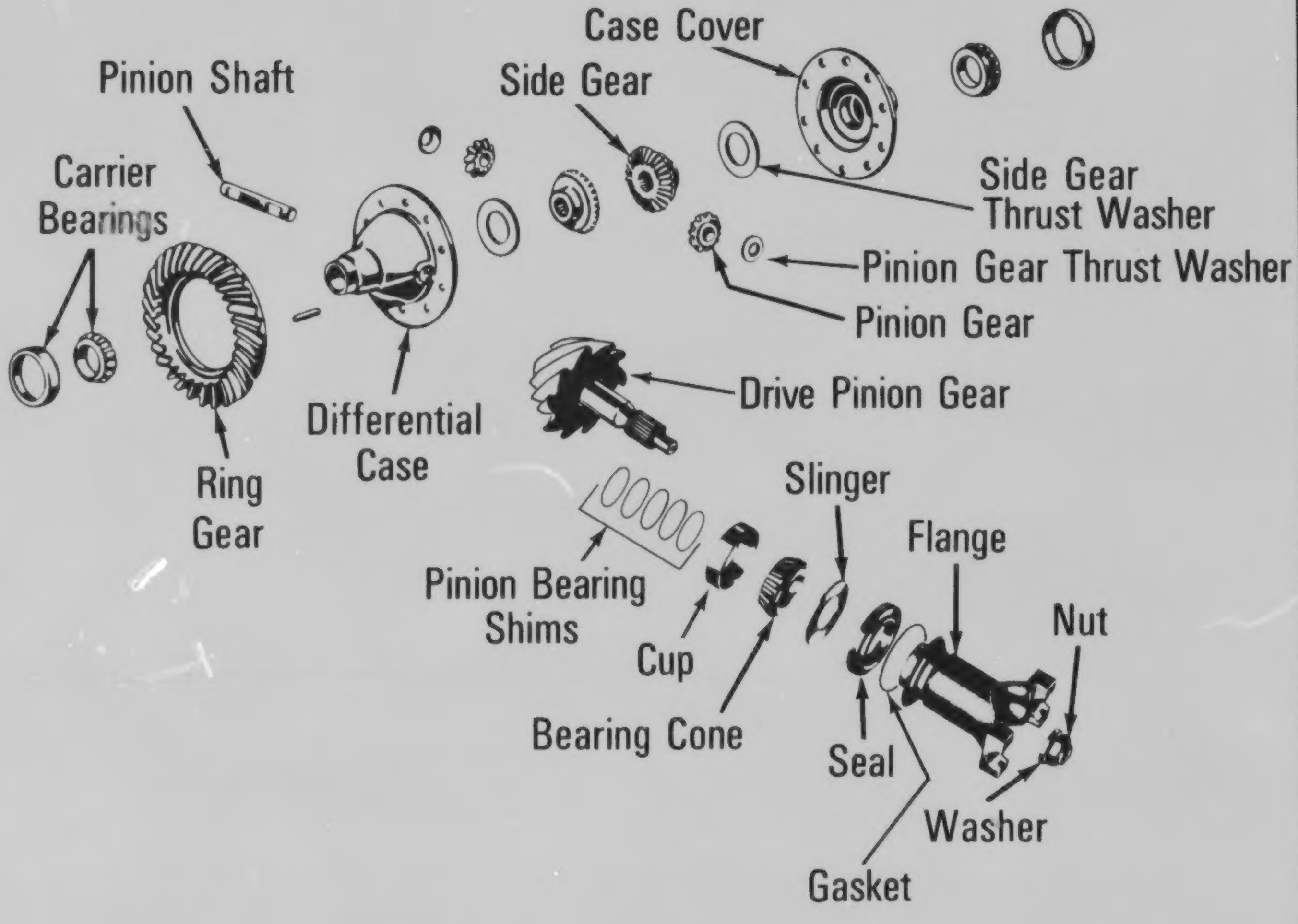

Axle Drive Gear
Axle Drive Pinion
Clutch Plates
Differential Case
Axle Shaft
Axle Shaft
Differential Side Gear
Differential Pinion

Power Flow Axle Shafts Turning at Same Speed

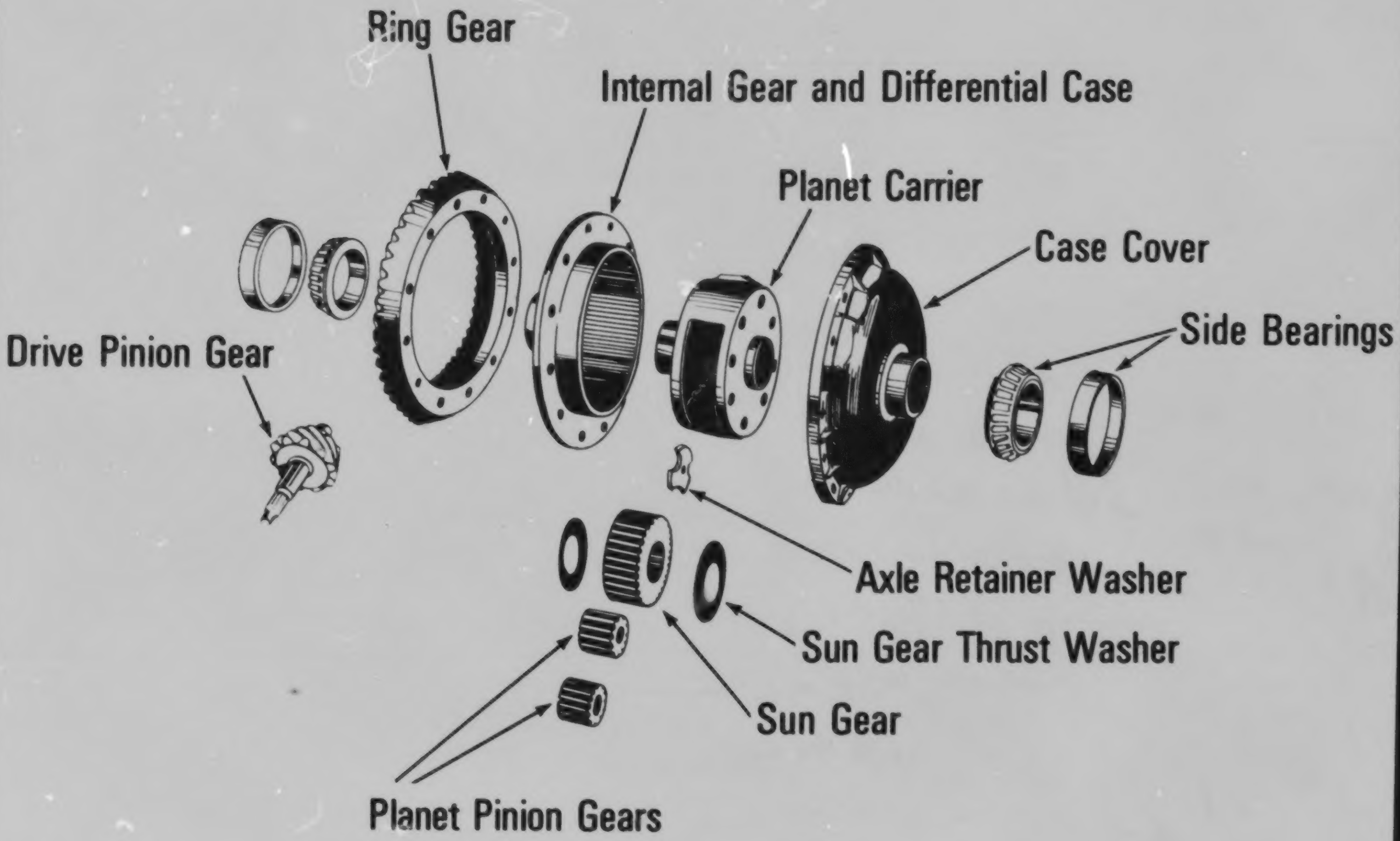

Axle Drive Gear
Axle Drive Pinion
Clutch Plates
Differential Case
Axle Shaft
Differential Side Gear
Differential Pinion

Power Flow Axle Shafts Turning at Different Speeds

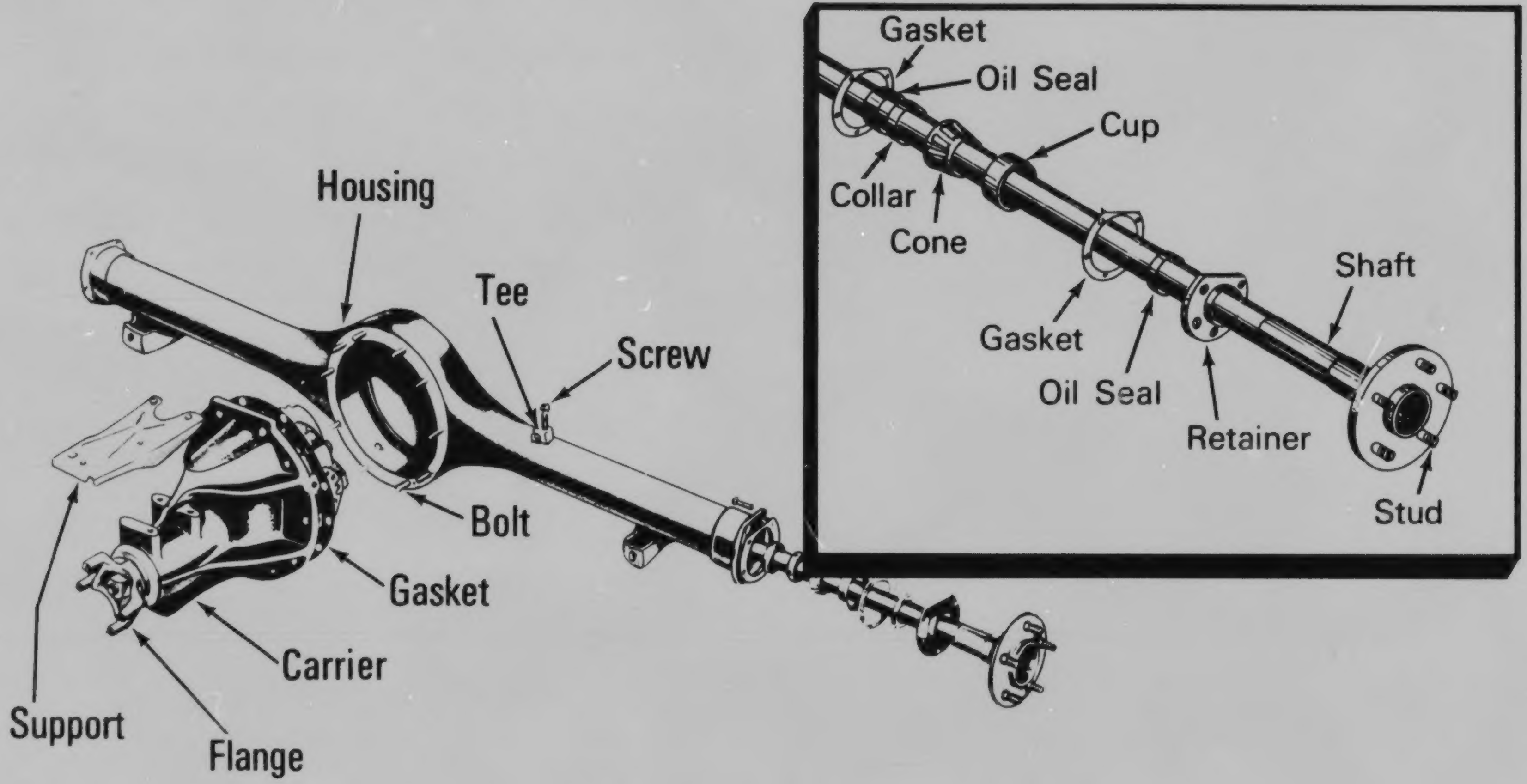
Parts of the Conventional Differential


Case Cover
Pinion Shaft
Side Gear
Carrier Bearings
Side Gear Thrust Washer
Pinion Gear Thrust Washer
Pinion Gear
Drive Pinion Gear
Differential Case
Ring Gear
Slinger
Flange
Pinion Bearing Shims
Nut
Cup
Bearing Cone
Seal
Washer
Gasket

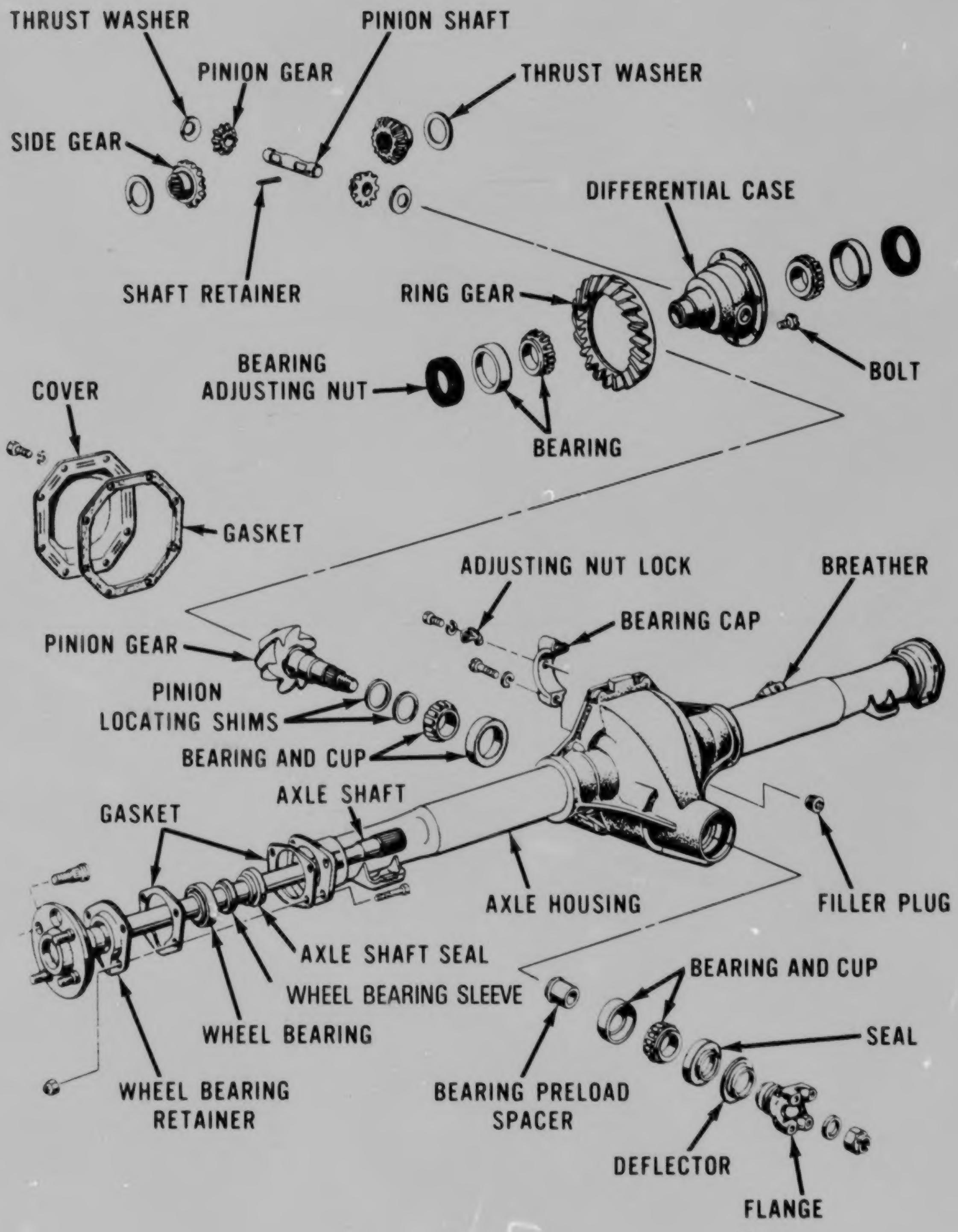
Parts of the Planetary Differential


Ring Gear
Internal Gear and Differential Case
Planet Carrier
Case Cover
Side Bearings
Drive Pinion Gear
Axle Retainer Washer
Sun Gear Thrust Washer
Sun Gear
Planet Pinion Gears

Removable Carrier Housing

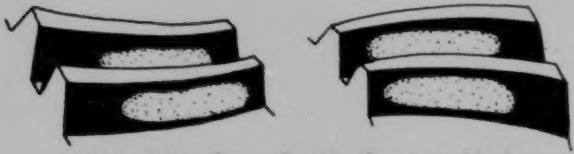

Gasket
Oil Seal
Cup
Collar
Cone
Shaft
Gasket
Oil Seal
Retainer
Stud
Housing
Tee
Screw
Bolt
Gasket
Carrier
Support
Flange

Integral Carrier Housing

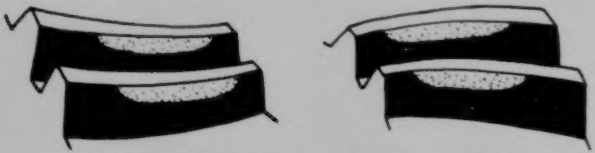

THRUST WASHER
PINION SHAFT
PINION GEAR
THRUST WASHER
SIDE GEAR
DIFFERENTIAL CASE
SHAFT RETAINER
RING GEAR
BEARING
ADJUSTING NUT
BOLT
COVER
BEARING
GASKET
ADJUSTING NUT LOCK
BREATHER
BEARING CAP
PINION GEAR
PINION
LOCATING SHIMS
BEARING AND CUP
AXLE SHAFT
GASKET
AXLE HOUSING
FILLER PLUG
AXLE SHAFT SEAL
BEARING AND CUP
WHEEL BEARING SLEEVE
WHEEL BEARING
SEAL
WHEEL BEARING
RETAINER
BEARING PRELOAD
SPACER
DEFLECTOR
FLANGE

Gear Tooth Contact Pattern Chart

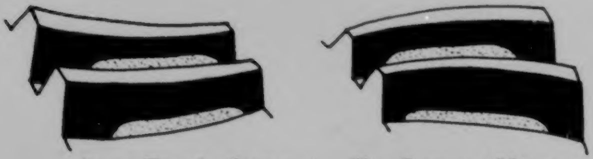
DRIVE COAST



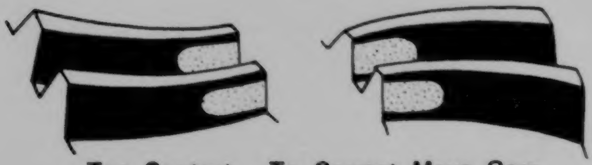
Ideal Ring Gear Tooth Contact Under Light Load



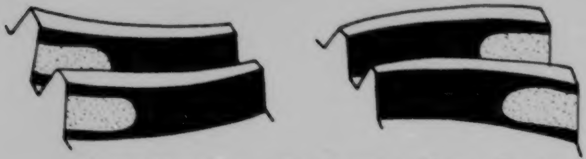
High Tooth Contact - To Correct Move Pinion Toward Gear



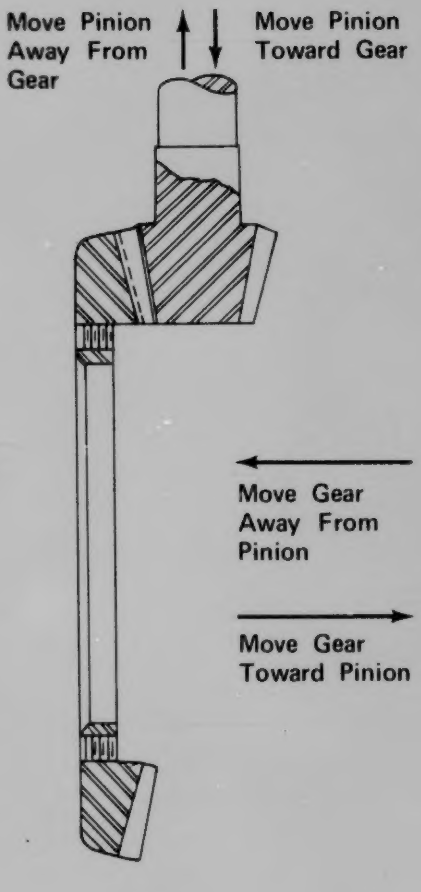
Low Tooth Contact - To Correct Move Pinion Away From Gear



Toe Contact - To Correct Move Gear Away From Pinion

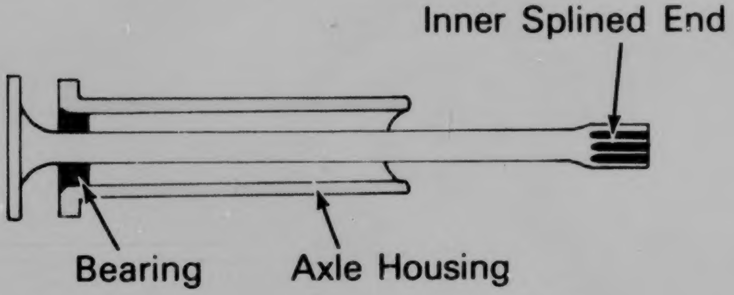


Heel Contact - To Correct Move Gear Toward Pinion

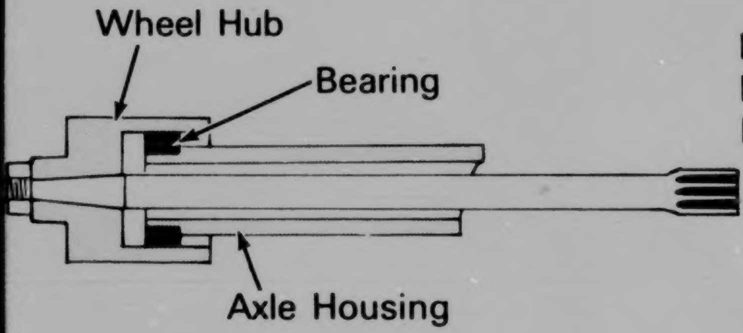

Move Pinion Away From Gear
Move Pinion Toward Gear
Move Gear Away From Pinion
Move Gear Toward Pinion

Pattern of ring gear tooth contact is shown along with corrective steps required to provide ideal contact.

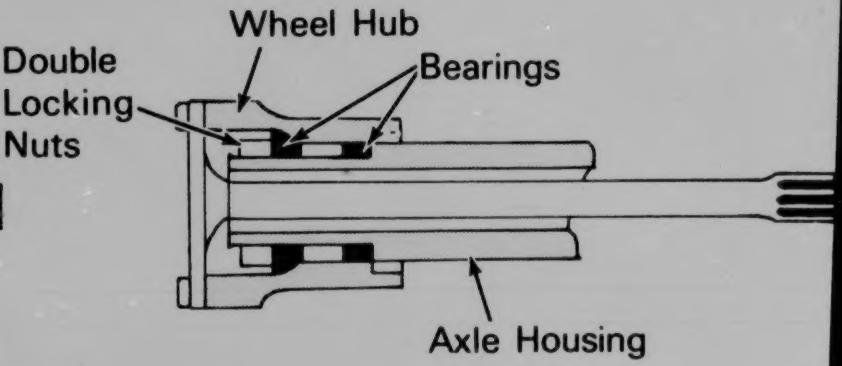
Types of Rear Axle Shafts


Inner Splined End
Bearing
Axle Housing

Semifloating

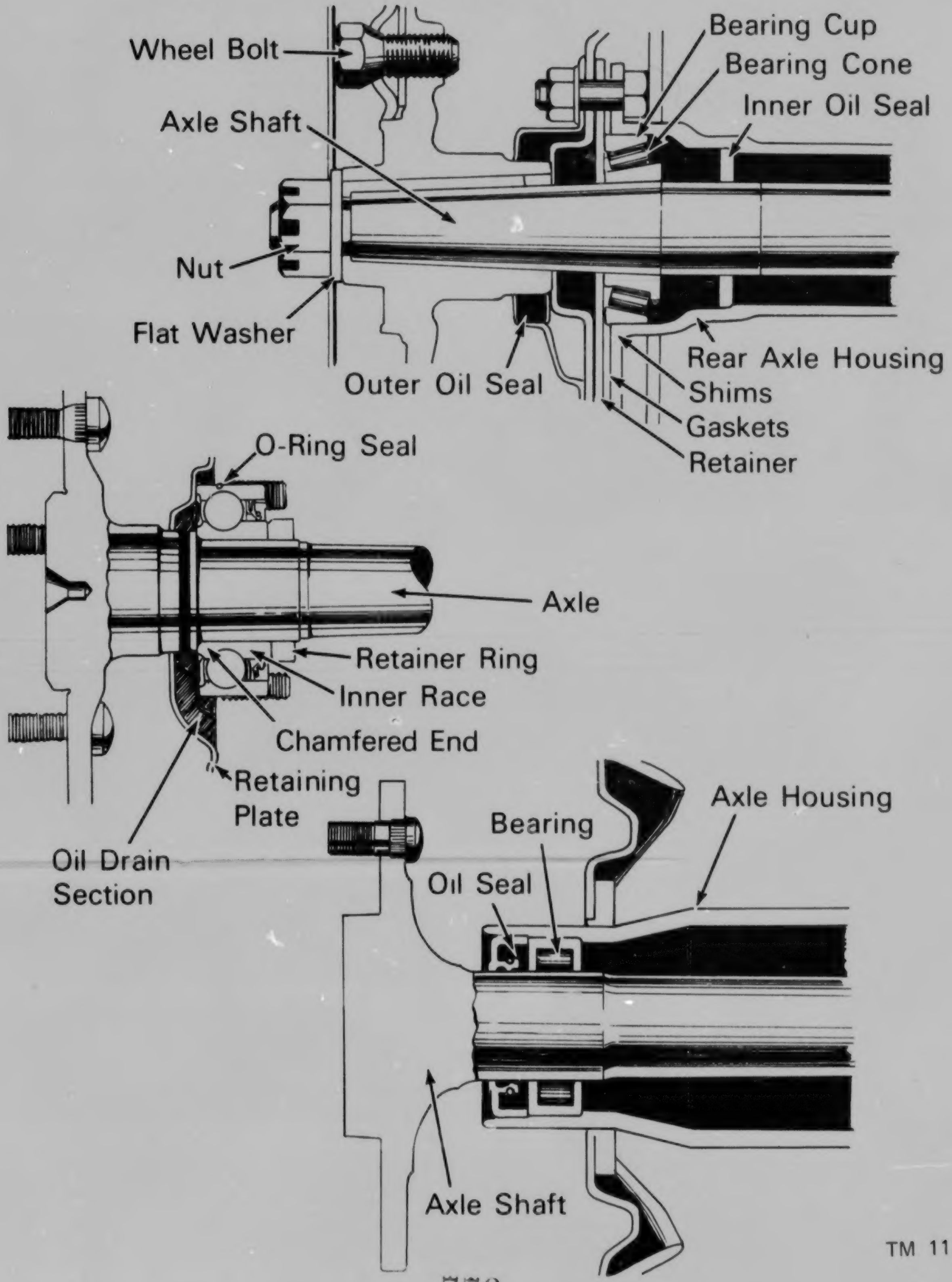

Wheel Hub
Bearing
Axle Housing

Three-Quarter Floating


Wheel Hub
Double Locking Nuts
Bearings
Axle Housing

Full-Floating

Types of Rear Axle Bearings


Wheel Bolt
Axle Shaft
Nut
Flat Washer
Bearing Cup
Bearing Cone
Inner Oil Seal
Outer Oil Seal
Rear Axle Housing
Shims
Gaskets
Retainer
O-Ring Seal
Axle
Retainer Ring
Inner Race
Chamfered End
Retaining Plate
Oil Drain Section
Bearing
Oil Seal
Axle Housing
Axle Shaft

REAR AXLE
UNIT IV

JOB SHEET #1--MEASURE BACKLASH BETWEEN RING GEAR AND DRIVE PINION

I. Tools and equipment

   A. Universal dial indicator set

   B. Torque wrench

   C. Sockets, 1/2" - 15/16" (12 mm - 24 mm)

   D. Removable carrier assembly

II. Procedure

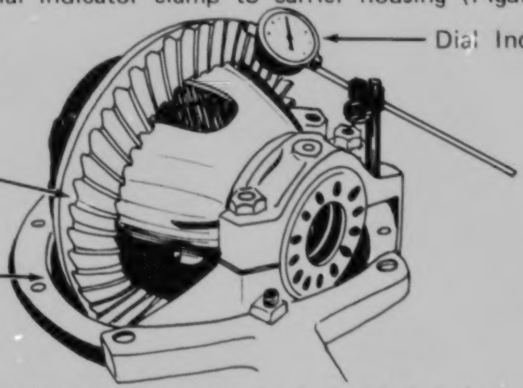
   A. Secure carrier housing in bench vise or suitable holding fixture

   B. Clean all lubricant and any other contamination from assembly, particularly the gear teeth, and air dry

   (NOTE: Bearing retainer caps should be at specified torque and drive pinion preload should be correct.)

   C. Attach dial indicator clamp to carrier housing (Figure 1)

FIGURE 1



Dial indicator set up to check backlash between ring and pinion. Hold pinion still while moving ring gear back and forth.

   D. Attach dial indicator and required linkage so that the indicator stem is set at a 90° angle to ring gear tooth face

   (NOTE: See Figure 1.)

JOB SHEET #1

E. Hold drive pinion flange stationary during the test

F. Rotate the ring gear in each direction through the slack between the gear teeth

(NOTE: This is the backlash.)

G. Set the dial indicator to "0" with the ring gear at the end of the slack to measure the backlash

H. Rotate the ring gear back through the slack

I. Read the indicator

(NOTE: This is the amount of backlash in thousandths of an inch.)

J. Compare your reading with manufacturer's specification, generally 0.005" to 0.008" (0.1270 mm - 0.2032 mm)

(NOTE: Measure backlash at four positions on the ring gear at approximately 90° intervals to obtain an average backlash reading.)

REAR AXLE
UNIT IV

JOB SHEET #2--TEST RING GEAR AND DRIVE PINION GEAR TOOTH CONTACT PATTERN

I. Tools and equipment

A. Pattern paste (red lead and motor oil mixed, white lead, or Prussian blue)

B. Sockets to fit drive pinion nut, 1/2" drive (12.7 mm)

C. Ratchet, 1/2" drive (12.7 mm)

D. Pinch bar

E. Small brush with stiff bristle

F. Removable carrier assembly

II. Procedure

A. Prepare the pattern paste as required

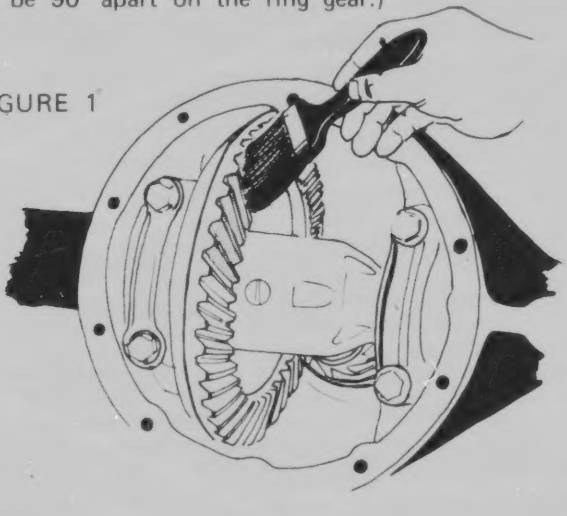
B. Secure the carrier assembly housing in bench vise or suitable fixture

C. Clean and air dry the drive pinion and ring gear teeth

D. Apply the pattern paste to both sides of the ring gear teeth (Figure 1)

(NOTE: Apply the paste only on four groups of four teeth each. The groups should be 90° apart on the ring gear.)

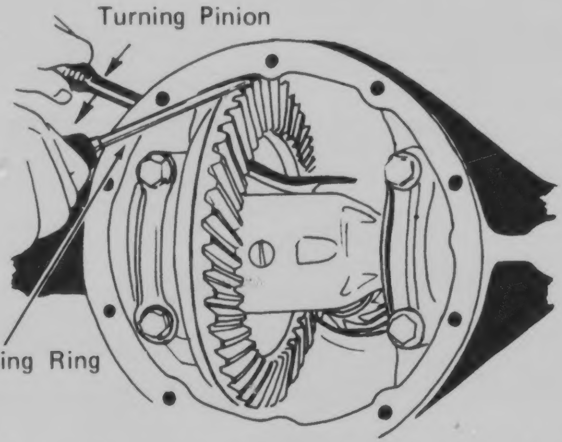
FIGURE 1



JOB SHEET #2

E. Turn the drive pinion while holding on to the ring gear so that one group of coated teeth passes back and forth across the pinion gear until a readable impression is produced on both sides of the ring gear teeth (Figure 2)

FIGURE 2



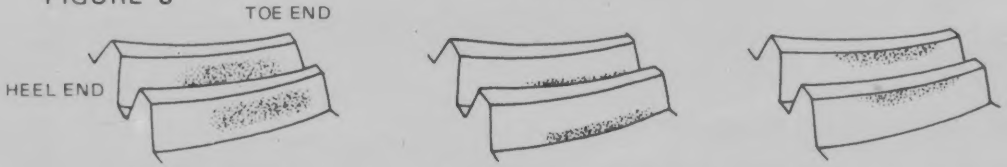
Cranking pinion while binding ring gear to produce a drive pattern.

F. Compare the ring gear tooth pattern with the patterns in Figure 3.

(NOTE: The caption under the pattern indicates the necessary corrective adjustments.)

FIGURE 3

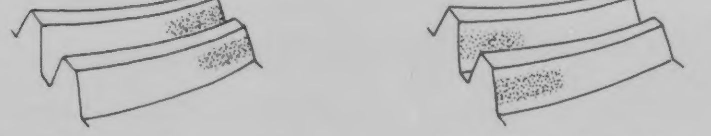
DRIVE



Ideal Ring Gear Tooth Contact Under Light Load

Low Tooth Contact-- To Correct Move Pinion Away From Gear

High Tooth Contact--To Correct Move Pinion Toward Gear

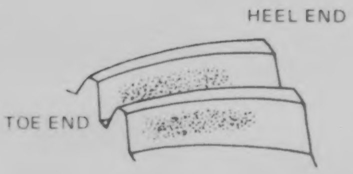


Toe Contact--To Correct Move Gear Away From Pinion

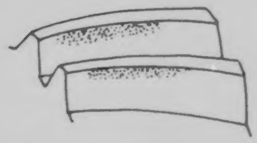
Heel Contact--To Correct Move Gear Toward Pinion

JOB SHEET #2

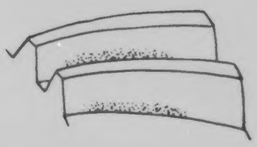
COAST



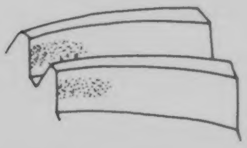
Ideal Ring Gear Tooth Contact Under Light Load



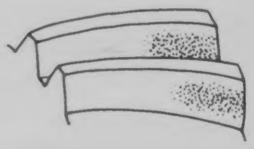
High Tooth Contact--To Correct Move Pinion Toward Gear



Low Tooth Contact--To Correct Move Pinion Away From Gear



Toe Contact--To Correct Move Gear Away From Pinion



Heel Contact--To Correct Move Gear Toward Pinion

G. Make contact patterns on the remaining three groups of teeth

H. Compare patterns from all four groups of teeth to develop an average pattern

(NOTE: The four patterns should be identical; if they are not, the ring gear has too much runout.)

REAR AXLE
UNIT IV

JOB SHEET #3--REPLACE DRIVE PINION SEAL

I. Tools and equipment

- A. Floor jack and jack stands
- B. Safety glasses
- C. Torque wrench, foot pound, 0 - 250 lb range (0 - 340 N·m range)
- D. Torque wrench, inch pound
- E. Sockets, 1" - 1 1/4" (25 mm - 31 mm), to fit drive pinion nut
- F. Flange holding tool
- G. Seal puller
- H. Seal driver
- I. Combination end wrenches, 3/8" - 5/8" (8 mm - 15 mm)
- J. Hammer
- K. Drain pan
- L. Gear lubricant
- M. Shop towels
- N. Nonhardening sealer

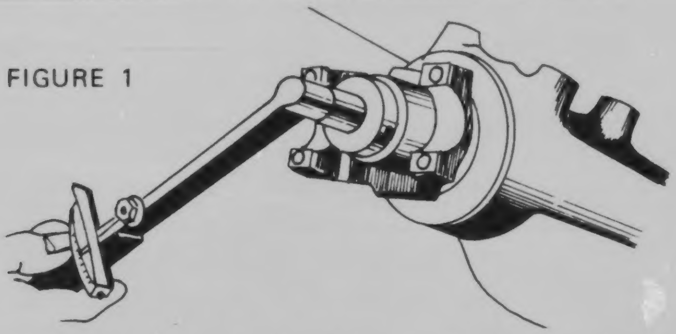
II. Procedure

- A. Raise vehicle
- B. Place jack stands on frame
- C. Remove drive shaft
- D. Check drive pinion bearing preload

JOB SHEET #3

E. Record preload for reference during reassembly (Figure 1)

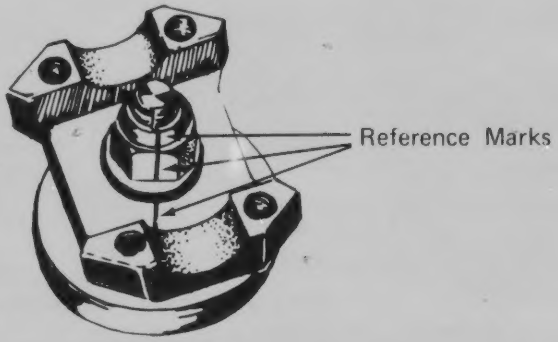
FIGURE 1



(NOTE: Measure the preload in the interval of backlash only.)

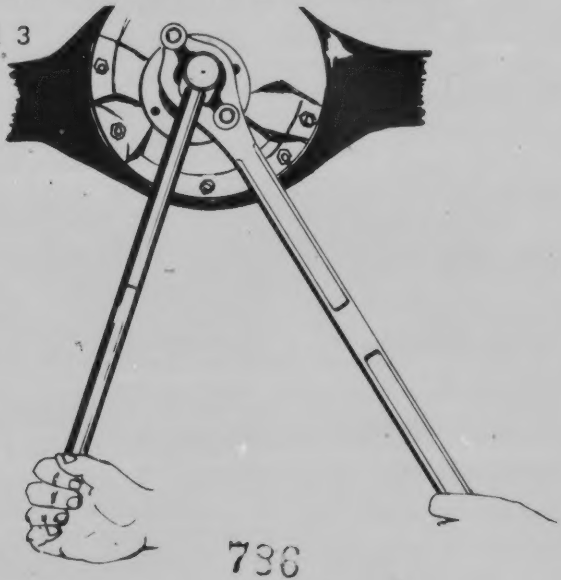
F. Mark the drive pinion flange, nut, and pinion shaft with a scribe (Figure 2)

FIGURE 2



G. Hold drive pinion flange with holding tool (Figure 3)

FIGURE 3



JOB SHEET #3

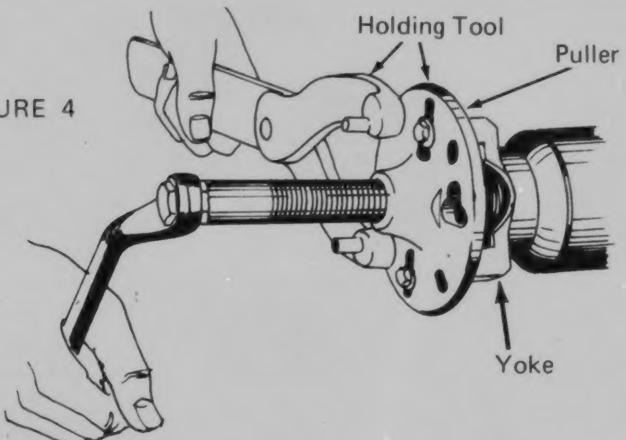
H. Remove pinion nut

I. Drain differential if possible; if not possible, place drain pan under pinion seal area to catch gear lube

J. Remove drive pinion flange with a puller (Figure 4)

(CAUTION: Do not drive off flange; this will distort it.)

FIGURE 4

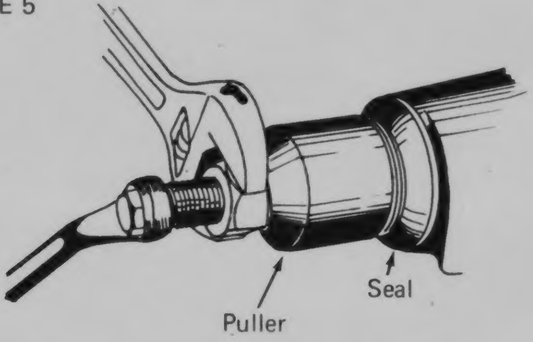


K. Inspect the flange for an excessive groove worn by the seal lip and for nicks and burrs on sealing surface

(NOTE: Small nicks and burrs may be removed with #400 sandpaper.)

L. Remove seal with puller (Figure 5)

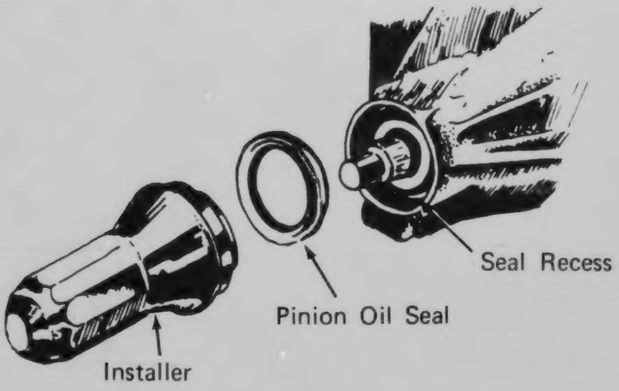
FIGURE 5



JOB SHEET #3

M. Clean seal recess in housing (Figure 6)

FIGURE 6


Seal Recess
Pinion Oil Seal
Installer

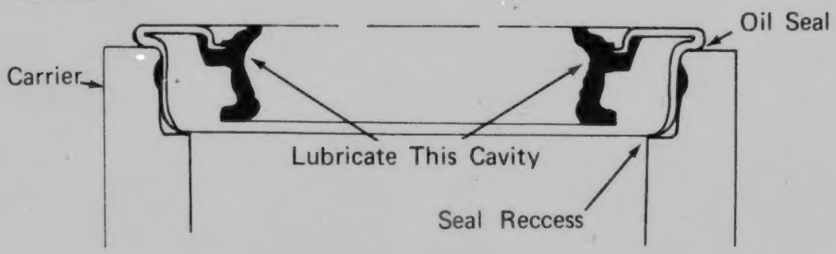
N. Apply a thin coat of nonhardening sealer to the outer surface of the seal

(NOTE: Install a new collapsible spacer to ensure that a quality job is produced.)

O. Install the seal with a seal driver, driving squarely and to the proper depth (Figure 7)

(NOTE: The lip should be facing inward.)

FIGURE 7

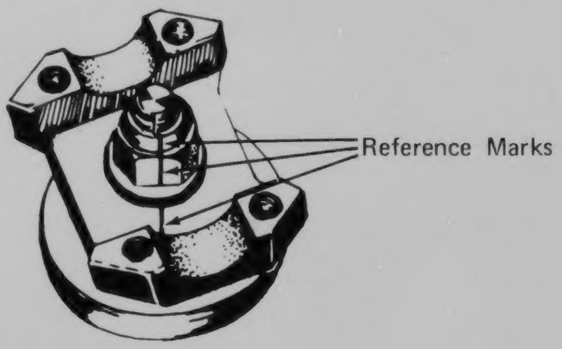

Oil Seal
Carrier
Lubricate This Cavity
Seal Reccess

P. Lubricate seal lip, flange sealing surface, and pinion splines with gear lube

JOB SHEET #3

Q. Align reference marks while installing flange on pinion (Figure 8)

FIGURE 8



(NOTE: Use a puller to install flange as required.)

R. Tighten the pinion nut if the pinion bearings are separated by a collapsible spacer

(NOTE: Tighten the pinion nut slightly; then check preload. Repeat this procedure until the preload is exactly what you recorded earlier or until it meets specifications.)

(CAUTION: Do not overtighten the preload or it will be necessary to replace the collapsible spacer. Never back off pinion nut to adjust preload.)

S. Torque the nut to manufacturer's specifications if the pinion bearings are separated by shims

T. Reinstall drive shaft

U. Fill the rear axle with gear lube of manufacturer's specified quality

V. Lower the vehicle to the floor

W. Road test with the instructor

REAR AXLE
UNIT IV

JOB SHEET #4--REPLACE BALL BEARING TYPE AXLE SHAFT BEARING AND SEAL

I. Tools and equipment

A. Floor jack and jack stands

B. Safety glasses

C. Lug wrench

D. Ratchet, 1/2" drive

E. Extension, 1/2" drive, 6" (15.24 cm)

F. Sockets, 1/2" drive, 1/2" - 13/16" (12 mm - 20 mm)

G. Hammer

H. Cold chisel

I. Slide hammer with axle puller and seal puller adaptor

J. Seal driver

K. Screwdriver, large standard

L. Hydraulic press

(NOTE: A suitable bearing puller may be used.)

M. Axle bearing press plate

N. Torque wrench, 1/2" drive

O. Shop towels

P. Rear axle lubricant

II. Procedure

(CAUTION: It is extremely important to use eye protection while performing this job.)

A. Raise vehicle

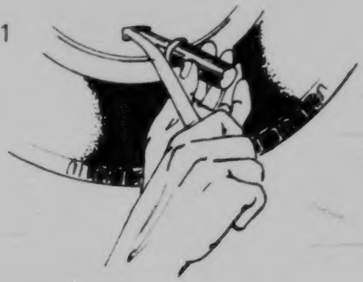
B. Place jack stands on frame

C. Remove the tire and wheel assembly

JOB SHEET #4

D. Back off brake shoes as required to remove brake drum (Figure 1)

FIGURE 1



E. Remove lug bolt clips and drum

(NOTE: On some models the drum and axle hub are attached to the axle by a large nut and tapered shaft.)

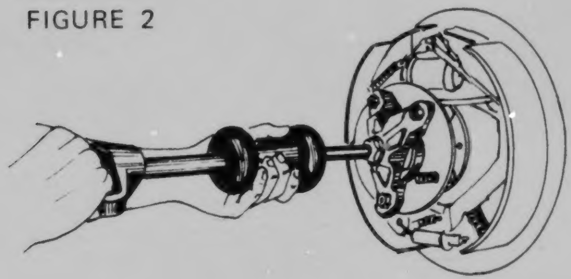
F. Clean dust from brake and axle flange

G. Remove axle retaining plate nuts through access hole in axle flange

H. Slide retainer plate off bolts

I. Attach axle puller and slide hammer to axle flange (Figure 2)

FIGURE 2



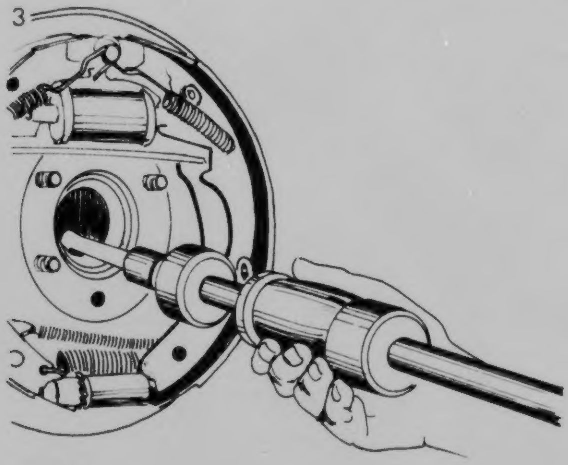
J. Pull axle

K. Restart one nut to hold brake backing plate in place

JOB SHEET #4

L. Pull axle shaft seal with puller and slide hammer if so equipped (Figure 3)

FIGURE 3

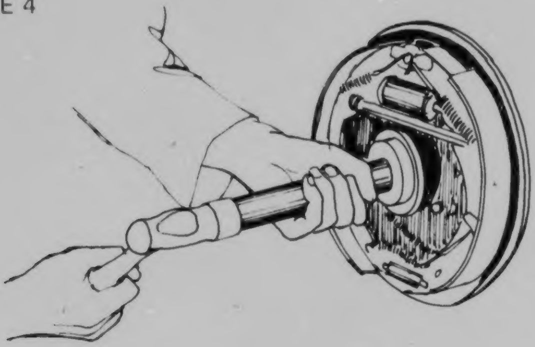


M. Clean seal recess in axle housing

N. Apply a light coat of nonhardening sealer on outer surface of the seal

O. Install seal, lip inward, with a seal driver until it seats in the housing (Figure 4)

FIGURE 4



P. Support the axle on a bench vise so that it rests on the bearing retainer ring

(CAUTION: Use eye protection.)

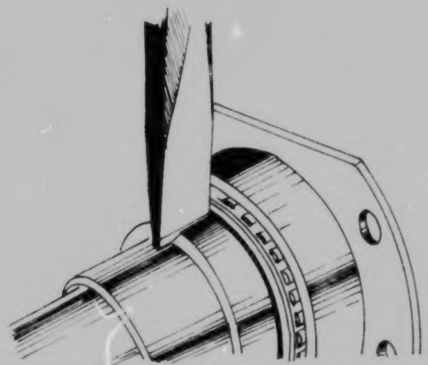
JOB SHEET #4

Q. Notch bearing retainer ring in one or more spots to loosen it (Figure 5)

(NOTE: Protect the seal surface on the axle.)

(CAUTION: Never use a cutting torch to remove bearings.)

FIGURE 5



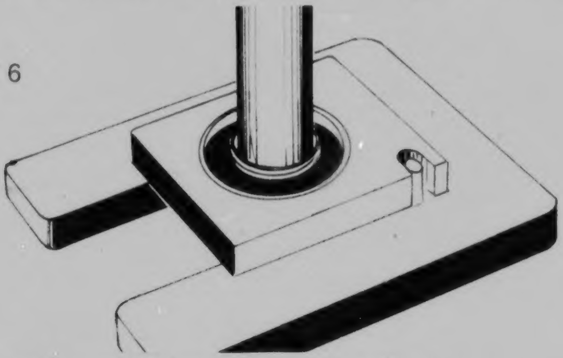
R. Place axle bearing press plate on the bearing (Figure 6)

S. Place the assembly in the hydraulic press

T. Press the bearing off (Figure 6)

(CAUTION: Cover the bearing while pressing; it could explode.)

FIGURE 6



U. Clean the axle and retainer plate with solvent

V. Inspect for deformation, worn axle splines, and seal surface nicks and burrs

(NOTE: Never wash sealed bearings in solvent. This will remove the lubricant and cause premature bearing failure.)

W. Replace retainer plate, bearing, and bearing retainer ring on axle shaft in that order

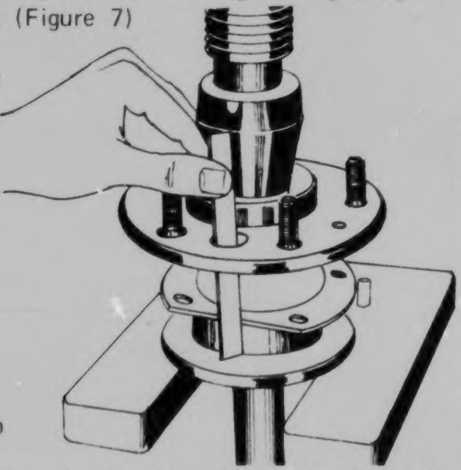
JOB SHEET #4

X. Place bearing press plate on hydraulic press

Y. Slide axle shaft through press plate so that the retainer ring is contacting the plate

Z. Press axle through bearing and retainer ring while guiding the retainer plate over the bearing seat (Figure 7)

FIGURE 7



AA. Lubricate the seal lip

BB. Remove the nut holding the brake backing plate in place

CC. Place the axle into the housing, being careful not to damage the seal

(NOTE: Be sure the axle splines are started in the side gear before exerting force on the axle to seat the bearing.)

DD. Place retainer plate on the bolts; start the nuts

EE. Torque nuts in an alternating pattern

FF. Replace the brake drum

GG. Replace drum retainer clips

HH. Replace tire assembly

II. Adjust the brakes

(NOTE: Adjust self-adjusting brakes also.)

JJ. Refill rear axle housing with grease specified by manufacturer

KK. Lower vehicle

LL. Road test with the instructor

REAR AXLE
UNIT IV

JOB SHEET #5--ADJUST DRIVE PINION BEARING PRELOAD WITH CARRIER ASSEMBLY REMOVED

I. Tools and equipment

A. Pinion flange holding tool

B. Torque wrench, foot pound, 0 - 250 lb range (0 - 340 N·m range)

C. Torque wrench, inch pound

D. Outside micrometer, 0" - 1" (0 - 25 mm)

E. Socket, to fit drive pinion nut, 1" - 1 1/4" (25 mm - 31 mm)

F. Drive pinion flange puller

G. Soft hammer

H. Assortment of shims for pinion preload adjustment

I. Gear lube

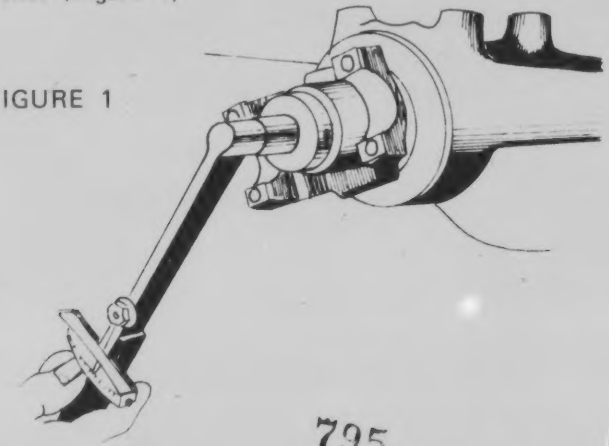
II. Procedure

A. Secure carrier assembly in bench vise or bench-holding fixture

B. Remove differential case from carrier assembly to allow free movement of drive pinion

C. Turn the drive pinion by the flange nut using the inch pound torque wrench and socket (Figure 1)

FIGURE 1



JOB SHEET #5

D. Record the reading of the torque wrench while the shaft is turning

(NOTE: This is the bearing preload.)

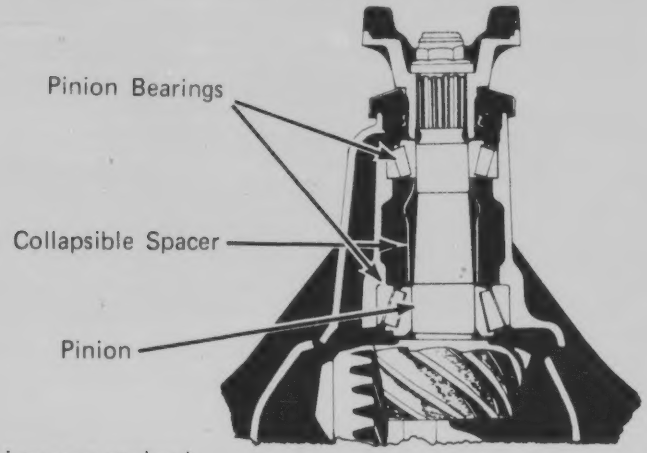
E. Compare the torque reading with manufacturer's specifications

F. Proceed as follows if change is required

1. On applications using a collapsible spacer to separate the pinion bearings (Figure 2)

   (NOTE: Refer to manufacturer's service guide.)

FIGURE 2



   a. To increase preload

      1) Tighten the pinion nut no more than a quarter turn using the flange holding tool and the foot pound torque wrench

      2) Recheck the pinion preload

      3) Continue this procedure until the preload is correct

   b. To reduce preload

      (NOTE: Too much preload indicates that the spacer is collapsed too much and will have to be replaced.)

      1) Remove the drive pinion flange

      2) Remove the drive pinion seal

JOB SHEET #5

3) Remove the drive pinion front bearing

4) Remove the collapsible spacer and replace with a new one

5) Reassemble parts in reverse order

6) Tighten the new drive pinion nut until the slack is removed from flange, bearing, and spacer

7) Readjust bearing preload to specifications

2. On applications using shims to separate drive pinion bearings--To increase preload make a thinner shim pack; to decrease preload make a thicker one

   (NOTE: Change a shim pack thickness only 0.002" [0.051 mm] at a time.)

   a. Remove drive pinion flange

   b. Remove pinion seal

   c. Remove pinion front bearing

   d. Replace shim pack with the adjusted shim pack

   e. Lubricate and replace drive pinion front bearing

      (NOTE: The drive pinion seal may be left out until the proper shim thickness is obtained.)

   f. Apply sealer to outer surface of seal and replace

   g. Lubricate flange and replace

   h. Torque new drive pinion nut to specifications

   i. Recheck preload

REAR AXLE
UNIT IV

JOB SHEET #6--SELECT PINION DEPTH SPACER WITH A PINION DEPTH GAUGE

I. Tools and equipment

   A. Appropriate pinion depth gauge

   B. Carrier support fixture

   C. Rear axle assembly (disassembled)

   D. Sockets, 1/2" drive, 7/16" - 1 1/4" (10 mm - 31 mm)

   E. Ratchet, 1/2" drive

   F. Torque wrench, foot pound

   G. Torque wrench, inch pound

   H. Combination end wrenches, 7/16 - 1 1/4" (10 mm - 31 mm)

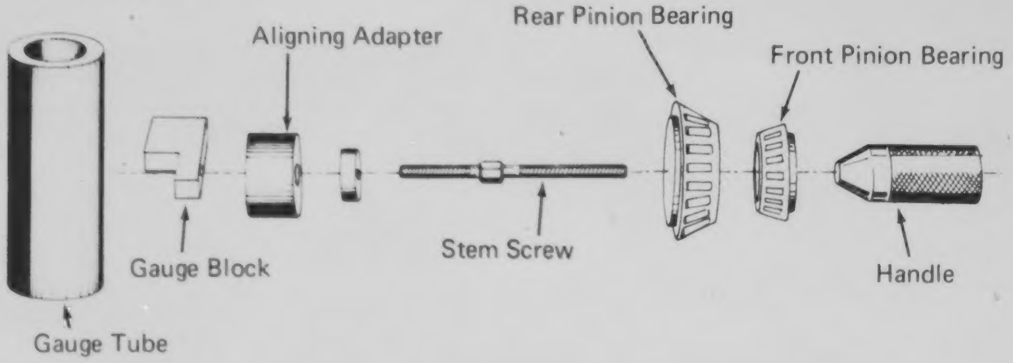
   I. Feeler gauge set

II. Procedure

(NOTE: The construction and assembly of gauge will vary among the different manufacturers, but the procedures for its use and for determining the proper spacer thickness will be the same.)

   A. Assemble the pinion depth gauge tool (Figure 1)

FIGURE 1


Aligning Adapter
Rear Pinion Bearing
Front Pinion Bearing
Gauge Block
Stem Screw
Handle
Gauge Tube

      1. Select the proper aligning adaptor and gauge disc for the differential being gauged

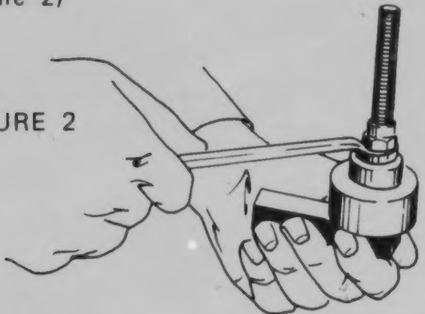
      2. Position the aligning adaptor and gauge disc on the small end of the stem screw

JOB SHEET #6

3. Thread the stem screw into the gauge (Figure 2)

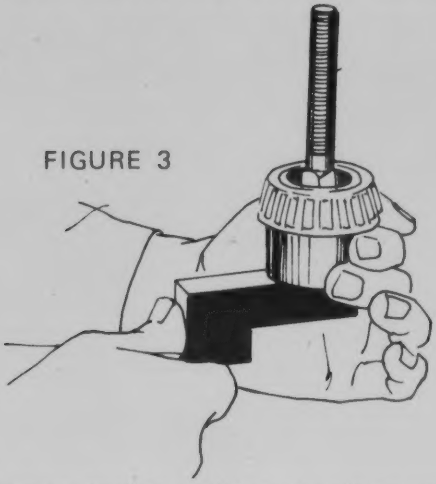
4. Torque the stem to approximately 20 foot pounds or 27.1 N·m (Figure 2)

FIGURE 2



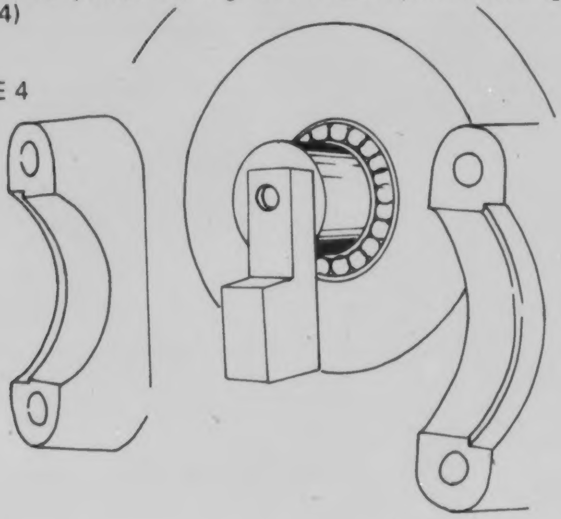
B. Place the new pinion bearing cone and roller assembly on the stem screw (Figure 3)

FIGURE 3



C. Insert the rear pinion bearing cone into the pinion bearing cup of the carrier (Figure 4)

FIGURE 4



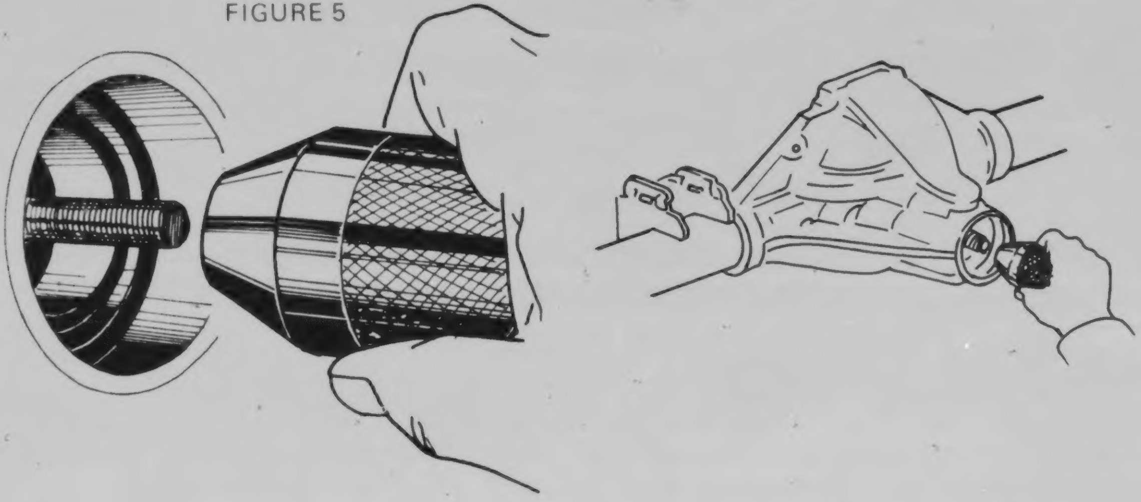
JOB SHEET #6

D. Place the front pinion bearing cone into the cup of the carrier

E. Thread the gauge handle onto the stem screw (Figure 5)

F. Tighten the handle to obtain pinion bearing preload (Figure 5)

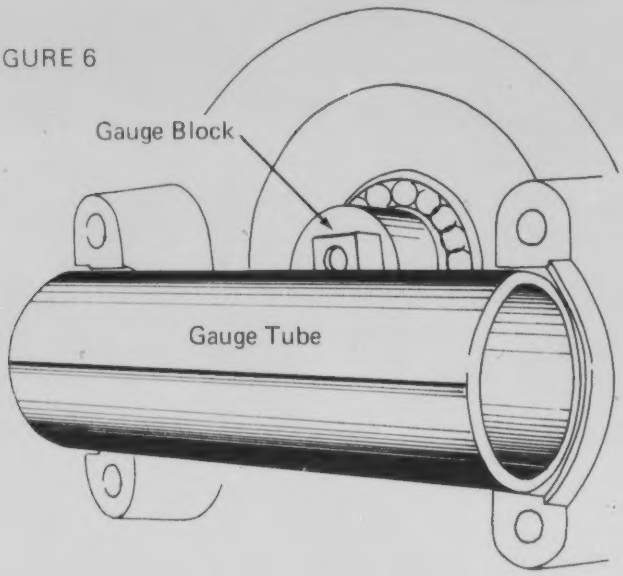
FIGURE 5



(NOTE: Rotate the bearings as much as possible as the handle is tightened to allow the bearings to align.)

G. Center the gauge tube in the differential bearing bore (Figure 6)

FIGURE 6



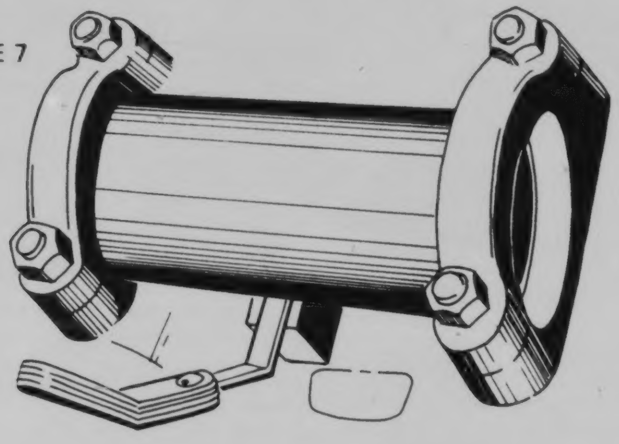
JOB SHEET #6

H. Install the bearing caps and torque to proper specifications

I. Use a feeler gauge to select the thickest feeler shim that will enter between the gauge tube and block (Figure 7)

J. Insert the feeler gauge directly along the gauge block to ensure correct readings (Figure 7)

FIGURE 7

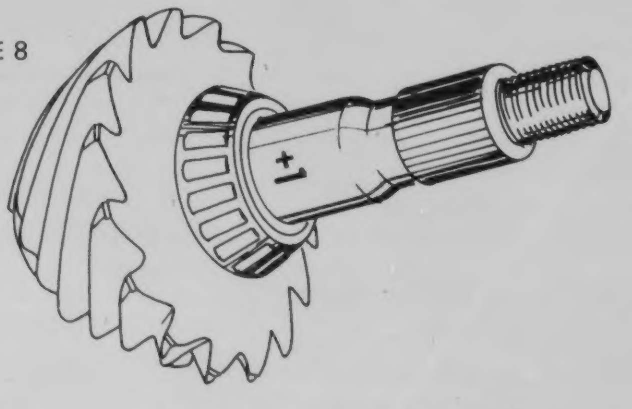


(NOTE: The feeler gauge fit between the gauge tube and block should be a slight drag feeling.)

K. Select the correct shim reading from the reading on the feeler gauge

(NOTE: If the service pinion is marked other than zero, you must subtract the plus markings from the feeler gauge reading and add the minus markings.)

FIGURE 8



(NOTE: Some manufacturers may have a conversion chart to select the shim from the revised feeler gauge reading.)

REAR AXLE
UNIT IV

JOB SHEET #7--ADJUST BACKLASH AND CARRIER BEARING PRELOAD

I. Tools and equipment

A. Removable carrier assembly

B. Spanner wrench

C. Torque wrench, foot pound

D. Socket, 1/2" drive, 3/4" (18 mm or 19 mm)

E. Combination end wrenches, 7/16" - 3/4" (10 mm - 19 mm)

II. Procedure

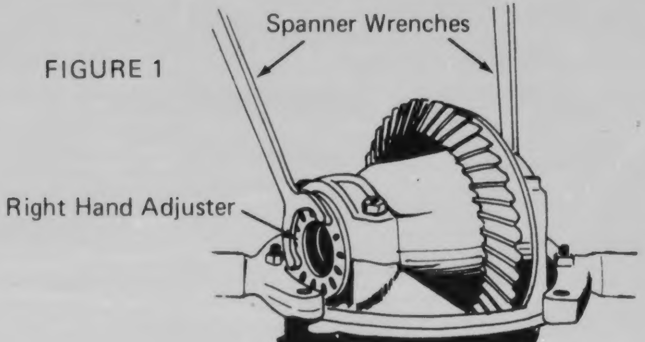
A. Secure the carrier assembly on a stand or vise

B. Remove carrier adjuster locks

C. Loosen the carrier cap bolts then retighten to approximately 10 foot pounds (13.55 newton-meters) with differential case assembly installed in the carrier housing

D. Use the spanner wrenches to turn adjusters inward equally until the bearing cups are seated against the bearing cones so that end play is "0" and some backlash is observable (Figure 1)

FIGURE 1

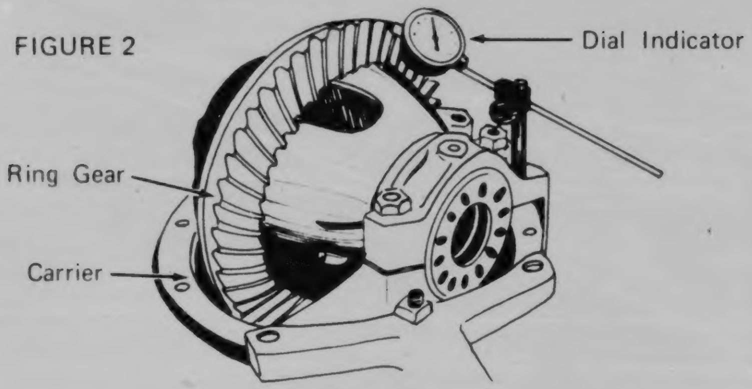


(NOTE: The ring gear should be rotated during adjustment to allow the bearings to align.)

JOB SHEET #7

E. Set up backlash gauge (Figure 2)

FIGURE 2



F. Turn both adjusters in the same direction to move the ring gear towards the drive pinion until backlash is 0.0005" (0.0127 mm) with "0" end play

G. Torque the carrier cap bolts on the ring gear side to specified torque

H. Tighten the adjuster opposite the ring gear to obtain specified backlash

(NOTE: Care should be taken not to exceed maximum backlash; this would overpreload the bearings.)

I. Torque the last two cap bolts

J. Install adjuster locks

K. Check the gear tooth contact pattern

REAR AXLE
UNIT IV

JOB SHEET #8--REMOVE AND REPLACE REAR AXLE HOUSING ASSEMBLY

I. Tools and equipment

   A. Floor jack and jack stands

   B. Safety glasses

   C. Torque wrench

   D. Combination end wrenches, 3/8" - 15/16" (8 mm - 24 mm)

   E. Sockets, 1/2" drive, 3/8" - 15/16" (8 mm - 24 mm)

   F. Ratchet, 1/2" drive

   G. Extension, 1/2" drive, 6" (15.24 mm)

   H. Vise grips

   I. Hammer

   J. Tubing wrenches, 3/8" and 5/8" (8 mm and 15 mm)

   K. Deep sockets, 1/2'' drive, 11/16'' and 3/4'' (16 mm and 19 mm)

   L. Common pliers

   M. Penetrating oil

   N. Brake fluid

   O. Gear lubricant

II. Procedure for removing rear axle housing

   A. Raise the vehicle

   B. Support vehicle with jack stands on the frame so the axle will hang free

   C. Remove the tires and wheel assembly

   D. Spray all the attaching bolts and nuts with penetrating oil

   E. Prop brake pedal in the "up" position with a wooden block

   F. Disconnect brake hose at the body support

JOB SHEET #8

G. Disconnect emergency brake cables at round eyelets

H. Disconnect emergency brake cable housing at body supports

I. Disconnect rear shock absorbers at the bottom

(NOTE: On coil spring applications, a jack should support the axle housing before shocks are disconnected.)

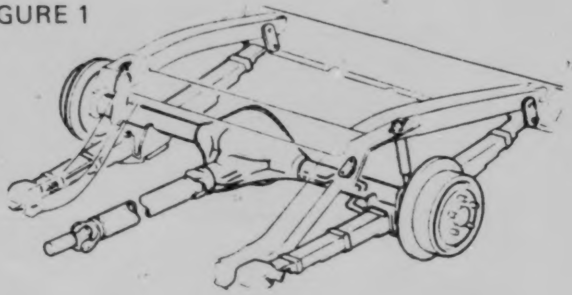
J. Disconnect rear axle supports

1. On leaf spring type (Figure 1)

    a. Disconnect spring U-bolts

    b. Remove the rear assembly

FIGURE 1



2. On coil spring model (Figure 2)

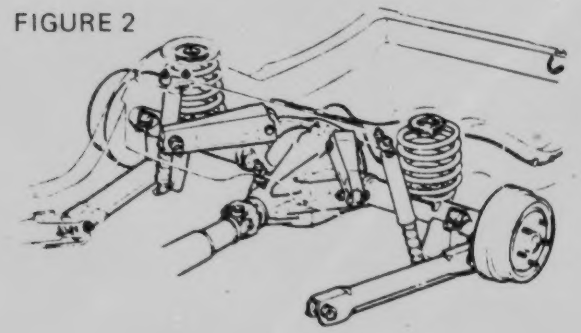
    a. Disconnect all stabilizer bars, upper control arm, and other accessories where they attach to the rear axle housing

    b. Lower the axle on the jack until the springs are free

    c. Remove bolts from lower control arm

    d. Remove rear axle assembly

FIGURE 2



JOB SHEET #8

III. Procedure for installing rear axle assembly

- A. Place axle housing on the jack
- B. Align axle housing under the vehicle
- C. Connect rear axle supports
  - 1. On leaf spring type
    - a. Align spring tie bolt with pilot hole in axle plate
    - b. Install U-bolts on springs
    - c. Torque the U-bolts in alternating sequence
  - 2. On coil spring type
    - a. Align lower control arms with axle housing brackets and install bolts
    - b. Align upper control arms with axle housing brackets and install bolts
    - c. Install coil springs
    - d. Raise the axle and attach lower ends of shock absorbers
- D. Reconnect stabilizers and other accessories connected to the axle housing

  (NOTE: Do not tighten bolts on control arms until the vehicle is sitting level with full weight on the tires.)
- E. Reconnect and adjust emergency brake cable
- F. Reconnect hydraulic brake hose
- G. Bleed system
- H. Replace tires and wheel assembly
- I. Adjust brakes
- J. Raise the rear axle housing until the full weight of the vehicle is on it

  (CAUTION: Jack stands should remain in place.)

JOB SHEET #8

K. Tighten all control arm bushing bolts

L. Fill differential with lubricant

(NOTE: Check manufacturer's specifications on nonslip differential lub.)

M. Lower vehicle

N. Road test with instructor

REAR AXLE
UNIT IV

JOB SHEET #9--DISASSEMBLE, INSPECT, REASSEMBLE, AND ADJUST AN INTEGRAL CARRIER REAR AXLE

I. Tools and equipment

   A. Carrier support fixture

   B. Sockets, 1/2" drive, 7/16" - 1 1/4" (10 mm - 31 mm)

   C. Ratchet, 1/2" drive

   D. Pinion flange holding tool

   E. Pinion flange puller and installer

   F. Pinion seal puller

   G. Pinion seal driver

   H. Bearing pullers

   I. Bearing drivers

   J. Carrier housing spreader

   K. Combination end wrenches, 7/16" - 1 1/4" (10 mm - 31 mm)

   L. Combination dial indicator

   M. Micrometer, 0" - 1.000" (0 - 25 mm)

   N. Pinch bars, 2

   O. Scribe

   P. Hammer

   Q. Feeler gauge

   R. Torque wrench, foot pound

   S. Torque wrench, inch pound

   T. Pattern paste

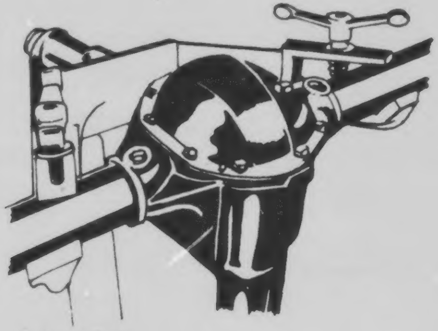
   U. Soft hammer, plastic or lead

JOB SHEET #9

II. Procedure for disassembly

A. Secure axle housing in holding fixture (Figure 1)

FIGURE 1



B. Clean outside of housing

C. Remove differential cover

D. Remove brake drums

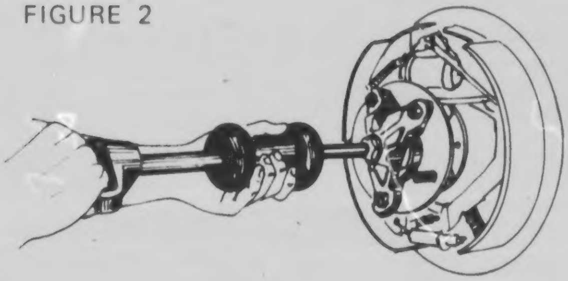
E. Remove axles

1. To remove axles without internal "C" locks

a. Remove axle bearing retaining plate bolts

b. Attach an axle puller (Figure 2)

FIGURE 2



c. Pull the axle

(NOTE: Use care to prevent the brake backing plate from falling and being damaged.)

JOB SHEET #9

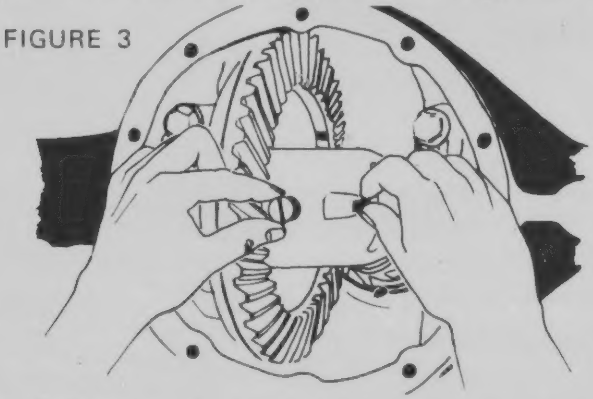
d. Replace one nut on the backing plate to hold it in place

2. To remove axles with internal "C" locks

   a. Remove the differential pinion shaft lock screw (Figure 3)

   b. Remove the differential pinion shaft (Figure 3)

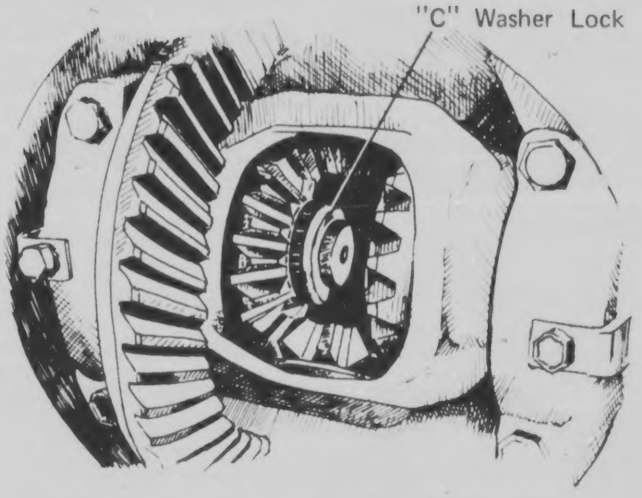
FIGURE 3



c. Push flanged end of axle shaft toward center of vehicle

d. Remove "C" locks from inside the differential case (Figure 4)

FIGURE 4

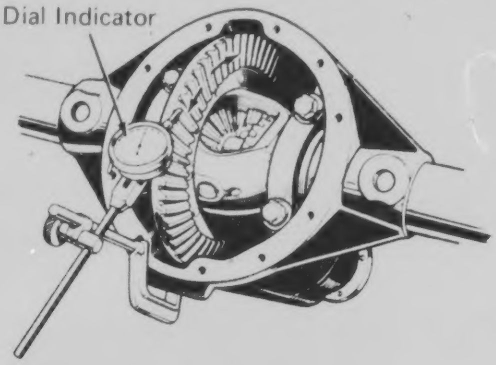


e. Pull the axle out of the differential case

JOB SHEET #9

F. Measure and record ring and pinion backlash (Figure 5)

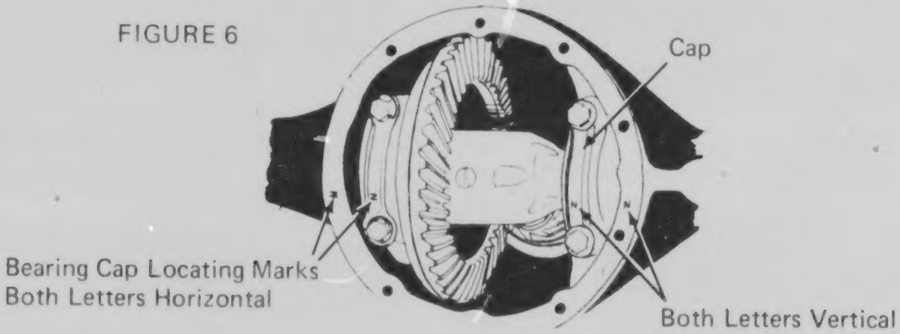
FIGURE 5


Dial Indicator

G. Make a tooth contact pattern for later reference

H. Mark carrier bearing caps for left and right sides (Figure 6)

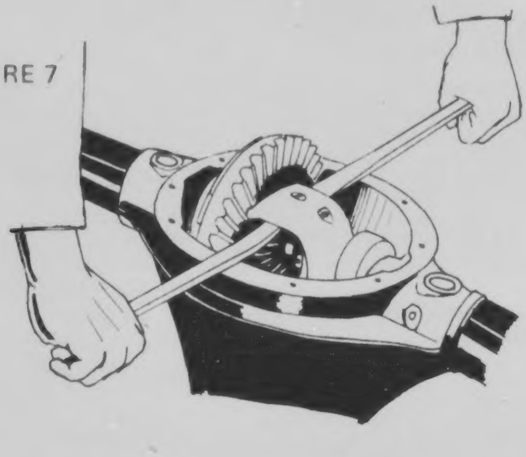
FIGURE 6


Cap
Bearing Cap Locating Marks
Both Letters Horizontal
Both Letters Vertical

I. Remove carrier bearing caps

J. Pry differential case out of carrier housing with two pinch bars (Figure 7)

FIGURE 7



JOB SHEET #9

(NOTE: If it is too tight, use the spreader to give just enough clearance to remove the case. See Figure 8.)

(CAUTION: Do not exceed manufacturer's limits on spreading the housing.)

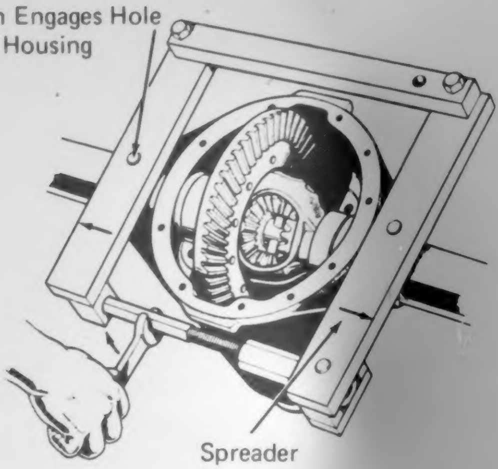


FIGURE 8

K. Mark the carrier bearing spacers as they were in the housing so that they can be used as references during assembly

L. Check and record drive pinion preload

M. Scribe mark the drive pinion, nut, and flange

N. Remove drive pinion flange

O. Remove drive pinion seal

P. Remove drive pinion front bearing cone

Q. Remove preload shims or collapsible spacer from pinion

(NOTE: Some shims may stick to the front bearing cone.)

R. Remove pinion from the carrier housing

S. Remove ring gear from differential case

T. Clean all parts and air dry

III. Procedure for inspection

A. Inspect bearing cones for roller heat discoloration, spalling, and pitting; inspect roller cage for wear or damage

JOB SHEET #9

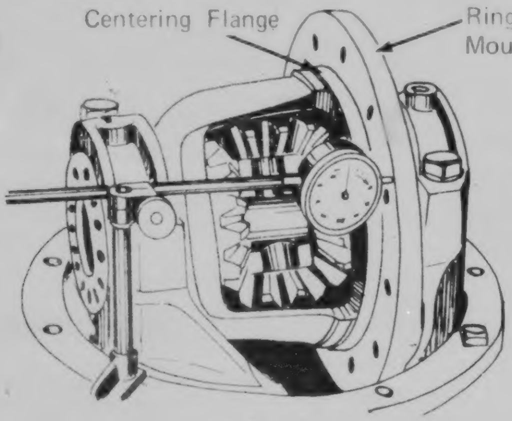
B. Inspect bearing cups for heat discoloration, spalling, or pitting

(NOTE: Bearing cup wear pattern can indicate problems that cause bearing failure such as misalignment, looseness, or lack of lubrication.)

C. Inspect drive pinion and ring gear teeth for scoring and chipping

(NOTE: Severe damage to either gear will warrant checking runout of the differential case, ring gear centering surface, and attaching flange with the dial indicator. See Figure 9.)

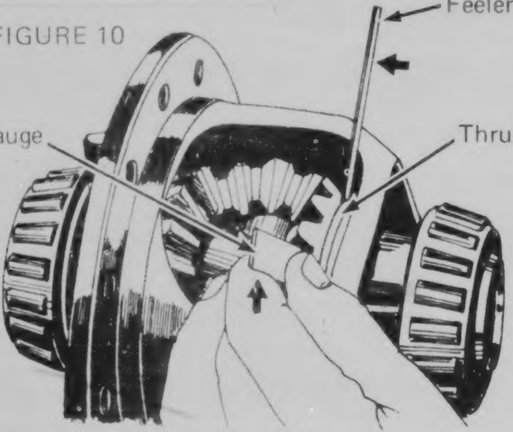
FIGURE 9


Centering Flange
Ring Gear Mounting Flange

D. Inspect axle side gears and differential pinion gears for wear and chipping

E. Measure side gear clearance with two feeler gauges of the same thickness (Figure 10)

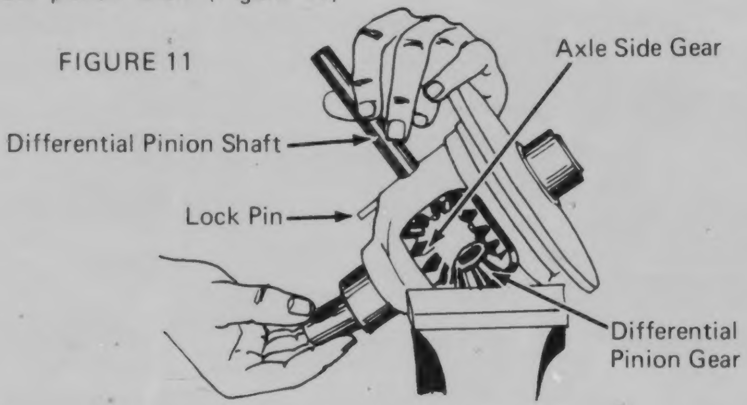
FIGURE 10


Feeler Gauge
Feeler Gauge
Thrust Washer

JOB SHEET #9

F. Disassemble differential unit by removing pinion shaft lock pin and then the pinion shaft (Figure 11)

FIGURE 11


Axle Side Gear
Differential Pinion Shaft
Lock Pin
Differential Pinion Gear

G. Rotate one axle gear to roll out the pinion gears while holding the other axle gear stationary

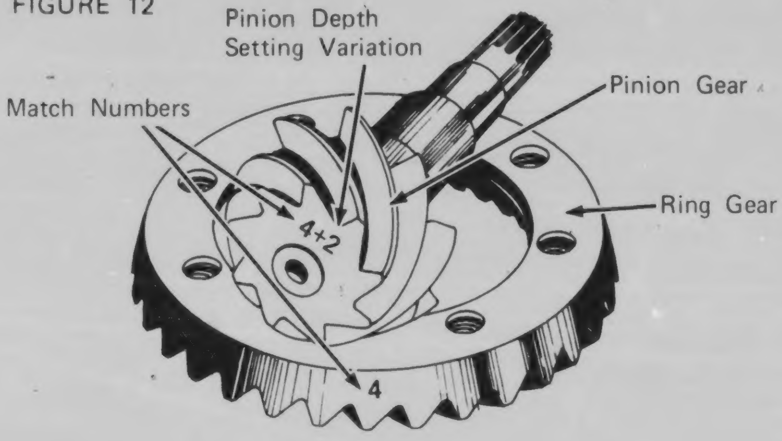
H. Remove the axle side gears

I. Inspect all thrust washers and thrust surfaces for scoring or excessive wear

J. Make a list of parts that require replacement

(NOTE: The ring and pinion gears are a matched set and must be replaced as a set. See Figure 12.)

FIGURE 12


Pinion Depth Setting Variation
Pinion Gear
Match Numbers
Ring Gear
4+2
4

IV. Procedure for assembly

A. Reclean all parts, tools, and work area

B. Lubricate all parts as they are assembled

JOB SHEET #9

C. Replace thrust washers on axle side gears

D. Place gears in differential case

E. Place one differential pinion gear in mesh with the axle side gears

F. Rotate one side gear until the pinion gear is opposite the case opening

G. Place the other pinion gear 180° from the first gear

H. Rotate one axle gear until both pinion gears align with shaft holes in the case

(NOTE: The pinion shaft may be used to align the gears.)

I. Install pinion gear thrust washers and pinion shaft

J. Install pinion shaft lock pin

K. Put three guide stud bolts in the ring gear

L. Install ring gear on differential case

M. Attach bolts and torque

N. Remove guide bolts

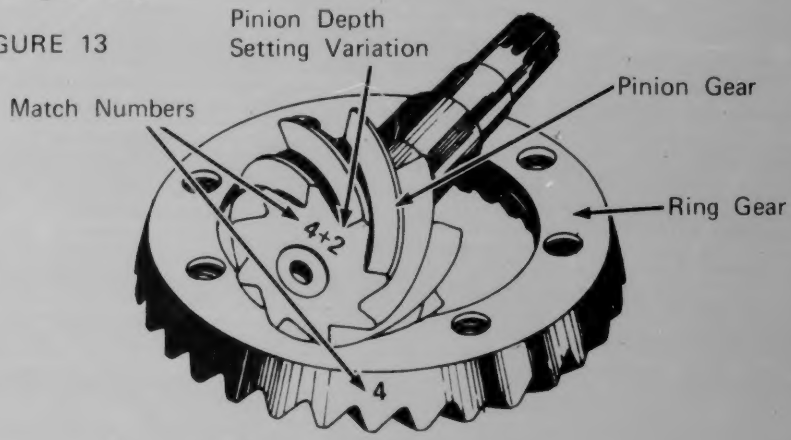
O. Replace guide bolts with attaching bolts and torque

P. Replace differential bearing cones if necessary

Q. Replace pinion bearings if necessary

(NOTE: If the same pinion is being reused, the same pinion depth shim will be reused. If a new pinion is used, refer to the numbers on the rear surfaces of the new and old gears, to the thickness of the old shim, and to the manufacturer's number code for the new pinion depth shim thickness. See Figure 13.)

FIGURE 13



JOB SHEET #9

(NOTE: The following rules are used to select the proper new spacer when the thickness of the old spacer is known.

1. As the pinion numbers go from 0 to minus [-] numbers, the pinion spacer gets thicker.
2. As the pinion numbers go from 0 to positive [+] numbers, the pinion spacer gets thinner.)

Example: The old pinion head number is -2 and the new pinion head number is +1. Subtract 0.003" (0.0762 mm) from the old shim thickness to obtain the shim thickness for the new pinion

R. Replace pinion bearing cups if necessary

(NOTE: Use a drive tool to install bearing cups.)

S. Install drive pinion with preload shims or new collapsible spacer in carrier housing

(NOTE: Add or subtract the same thickness on the old preload shim pack as was changed on the pinion spacer.)

T. Install front pinion cone

U. Install a spacer to replace the pinion flange; torque the pinion nut

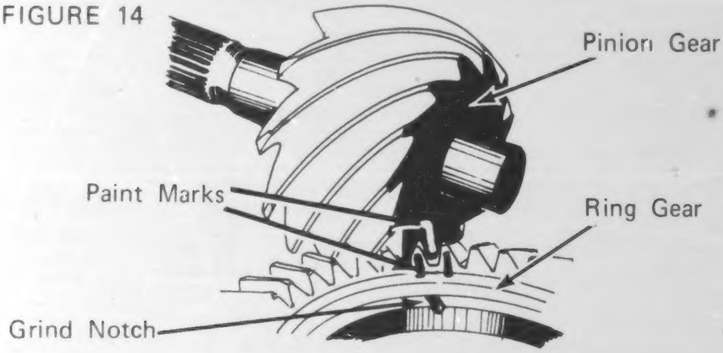
V. Check preload on models with preload shims; readjust shims as necessary

(NOTE: On models with collapsible spacer, do not set preload at this time.)

W. Install differential case into carrier housing using old shim pack

(NOTE: Align index marks on gear teeth for nonhunting gears. See Figure 14.)

FIGURE 14



JOB SHEET #9

X. Replace carrier bearing caps

Y. Torque the bolts

Z. Measure the backlash

AA. Check tooth contact pattern

BB. Make the necessary shim changes to correct the contact pattern and backlash

CC. Remove the pinion nut and spacer used in place of the pinion flange

DD. Install the pinion seal

EE. Install the pinion flange and nut

FF. Torque the pinion nut on models with preload shims

GG. Collapse the preload collapsible spacer and set the pinion bearing preload

HH. Replace axles

II. Replace brake drums

JJ. Adjust brakes

KK. Replace carrier inspection cover

REAR AXLE
UNIT IV

TEST

NAME ________________________________ SCORE ____________________

1. Discuss in writing the purposes of the rear axle assembly.

____

____

____

2. Match the terms on the right to the correct definitions. (Answers for "a" through "g" are on this page.)

______a. Set of gears in which the drive pinion gear is below the center line of the ring gear

______b. Set of gears in which any one drive pinion gear tooth contacts only a certain number of ring gear teeth; set with timing marks on the gear teeth

______c. Axle supports, retains, and drives the wheel; outer end of axle is supported by a bearing in the axle housing

______d. Method used to test the wiping action between the ring gear and drive pinion gear teeth to determine if they are properly adjusted

______e. Axle retains and drives the wheel; load is supported by means of a hub and bearing assembly on the axle housing

______f. Special traction differential that automatically transfers torque to the wheel that is not slipping when loss of drive force occurs in the other wheel

______g. Solution that indicates the area of contact between gear teeth; can be made of red lead and motor oil, white lead, or Prussian blue

1. Nonhunting gears
2. Pattern paste
3. Nonslip differential
4. Semifloating axle
5. Hypoid gearing
6. Tooth contact pattern test
7. Three-quarter floating axle

______h. Adjustment of antifriction bearings so that they are under mild pressure; tested by the amount of torque in inch pounds required to turn the shaft

______i. Unit that will drive both rear wheels at the same time but will allow them to turn at different speeds when negotiating turns

______j. Distance that one gear can be moved back and forth without moving the gear into which it is meshed

______k. Axle drives the wheel; wheel is supported and retained by a hub containing two roller bearings which are attached to the axle housing

______l. Distance separating two gear teeth that are meshed together

8. Differential

9. Full-floating axle

10. Preload

11. Backlash

12. Gear tooth clearance

3. Identify the parts of the gear tooth in the drawing below by writing the correct names in the blanks provided.

a. ____________

b. ____________

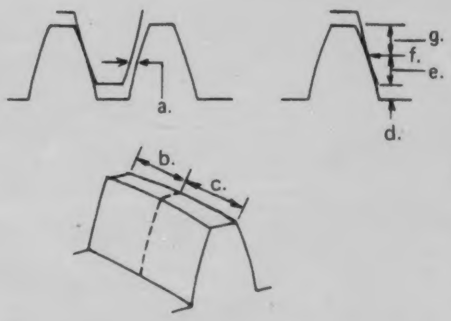
c. ____________

d. ____________

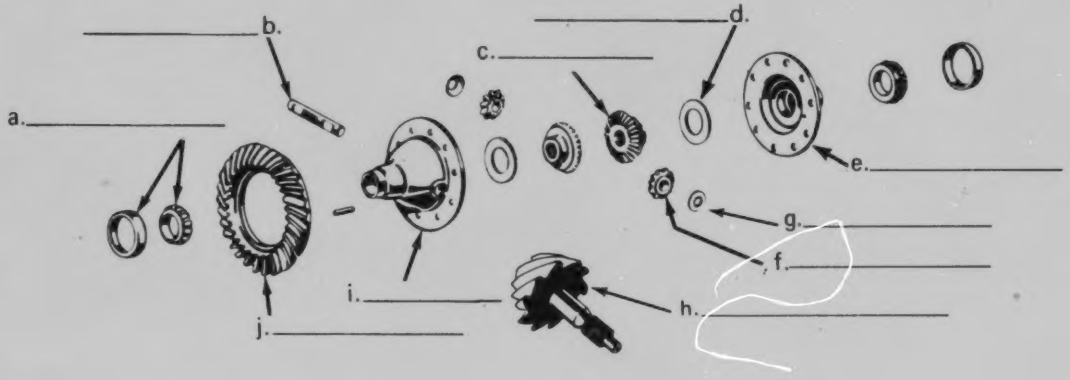
e. ____________

f. ____________

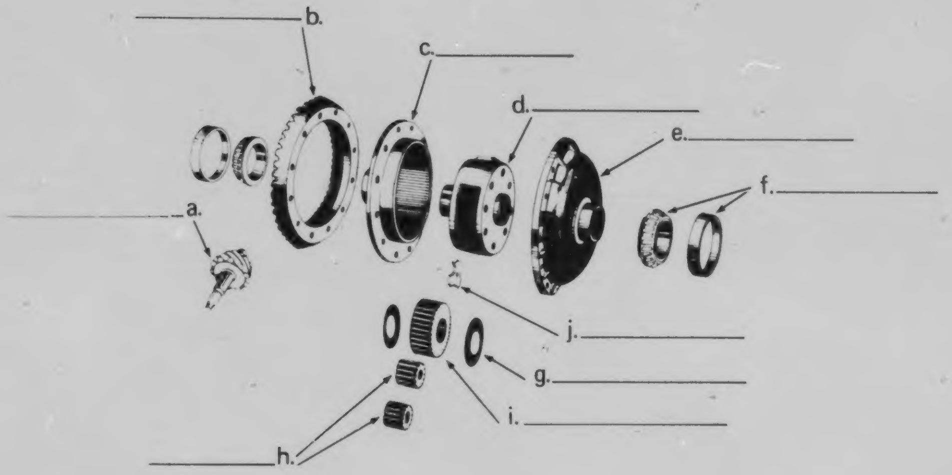
g. ____________



4. Identify the parts of the conventional differential in the drawing below by writing the correct names in the blanks provided.

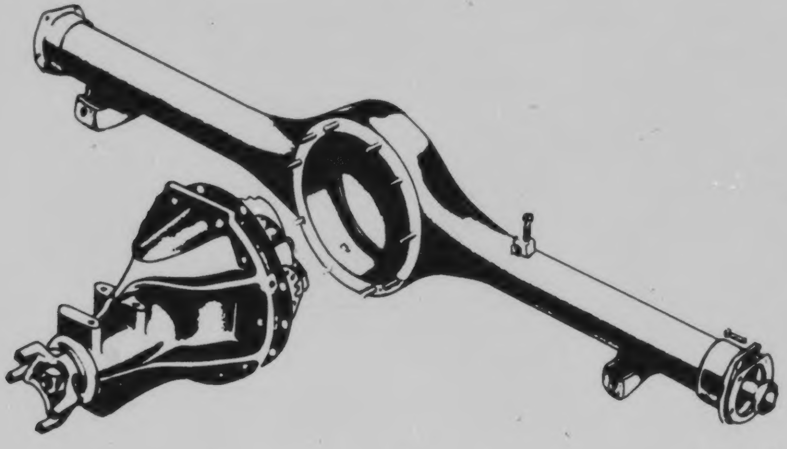


5. Identify the parts of the planetary differential in the drawing below by writing the correct names in the blanks provided.

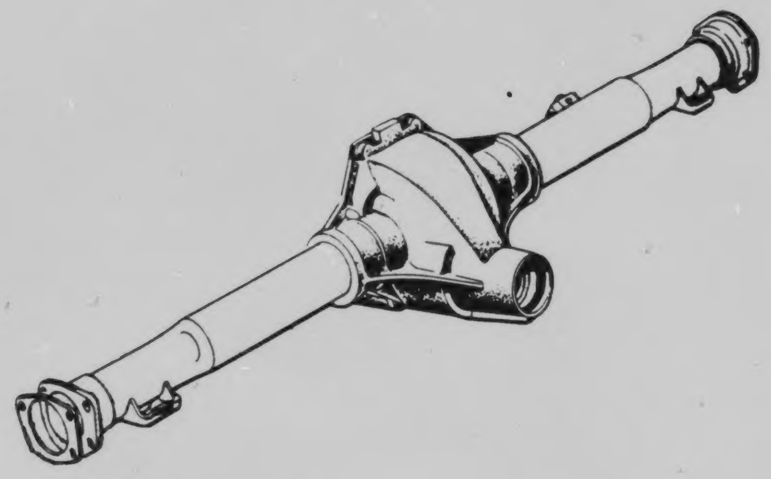


6. Identify the two types of differential carrier housings in the diagrams below by writing the correct names in the blanks provided.

a. ____________________



b. ____________________



7. Discuss the ideal ring gear and drive pinion tooth contact pattern.

   a. On drive side of tooth (convex side)

   ____

   ____

   ____

   ____

   b. On coast side of tooth (concave side)

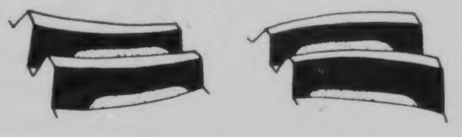
   ____

   ____

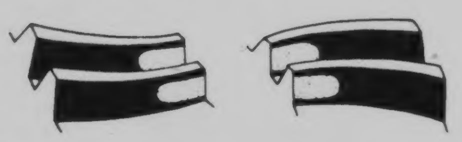
   ____

8. Match the types of ring gear tooth contact patterns on the right with the correct diagrams.

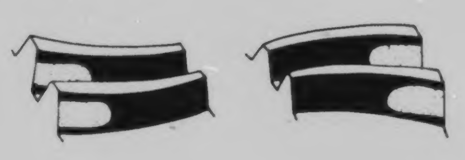
1. Heel contact
2. Low tooth contact
3. Ideal contact
4. High tooth contact
5. Toe contact



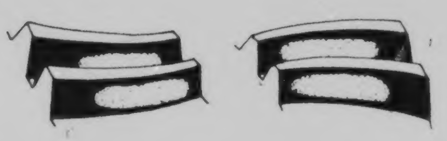
_____a.



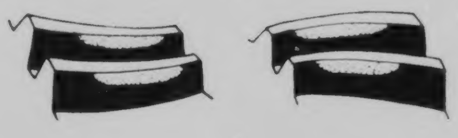
_____b.



_____c.

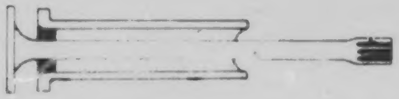


_____d.

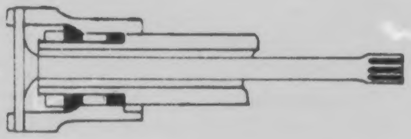


_____e.

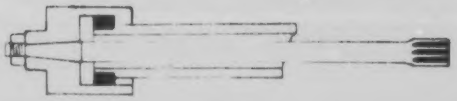
9. Identify the types of rear axle shafts in the diagrams below by placing the correct names in the blanks provided.



a. ______________________



b. ______________________



c. ______________________

10. List three types of rear axle bearings.

a. ______________________

b. ______________________

c. ______________________

11. Demonstrate the ability to:

a. Measure the backlash between a ring gear and drive pinion gear.

b. Test the ring gear and drive pinion gear tooth contact pattern.

c. Replace a drive pinion seal.

d. Replace a ball bearing type rear axle shaft bearing and seal.

e. Adjust the drive pinion bearing preload with carrier assembly removed.

f. Select pinion depth spacer with a pinion depth gauge.

g. Adjust backlash and carrier bearing preload.

h. Remove and replace a rear axle housing assembly.

i. Disassemble, inspect, reassemble, and adjust an integral carrier rear axle.

(NOTE: If these have not been accomplished prior to the test, ask the instructor when the above activities should be completed.)

REAR AXLE
UNIT IV

ANSWERS TO TEST

1. Discussion should include:

   a. To change the direction of power flow

   b. To provide a means by which the vehicle can corner without the rear wheels skidding

2. a. 5

   b. 1

   c. 4

   d. 6

   e. 7

   f. 3

   g. 2

   h. 10

   i. 8

   j. 11

   k. 9

   l. 12

3. a. Backlash

   b. Toe

   c. Heel

   d. Clearance

   e. Flank

   f. Pitch line

   g. Face

4. a. Carrier bearings
   b. Pinion shaft
   c. Side gear
   d. Side gear thrust washer
   e. Case cover
   f. Pinion gear
   g. Pinion gear thrust washer
   h. Drive pinion gear
   i. Differential case
   j. Ring gear
5. a. Drive pinion gear
   b. Ring gear
   c. Internal gear and differential case
   d. Planet carrier
   e. Case cover
   f. Side bearings
   g. Sun gear thrust washer
   h. Planet pinion gears
   i. Sun gear
   j. Axle retainer washer
6. a. Removable
   b. Integral
7. Discussion should include:
   a. On drive side of tooth (convex side)
      1) Should be centrally located between the top and bottom
      2) Can be slightly closer to the toe end
      3) Tends to spread toward the heel of the tooth as the load increases

b. On coast side of tooth (concave side)

1) Should be centrally located between the top and bottom

2) May be a little longer and slightly closer to the toe end

8. a. 2

b. 5

c. 1

d. 3

e. 4

9. a. Semifloating

b. Full-floating

c. Three-quarter floating

10. a. Ball bearing

b. Tapered roller bearing

c. Flat roller bearing

11. Performance skills evaluated to the satisfaction of the instructor

AUTOMATIC TRANSMISSION SERVICE
UNIT V

UNIT OBJECTIVE

After completion of this unit, the student should be able to perform transmission tune-ups and conduct tests that require the transmission to be in the vehicle. This knowledge will be evidenced through demonstration and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with automatic transmission service to the correct definitions.
2. Select from a list the repairs which can be performed with the transmission in the vehicle.
3. Select from a list items to include in an automatic transmission tune-up.
4. Match tests that can be performed with the transmission in the vehicle to the correct purposes.
5. Distinguish between the types of automatic transmission fluid.
6. Arrange in order the procedure for checking automatic transmission fluid level.
7. Match fluid conditions to possible transmission problems.
8. List types of transmission filters.
9. Demonstrate the ability to:
    a. Perform a road test for transmission diagnosis.
    b. Replace an extension housing bushing and seal.
    c. Tune-up an automatic transmission.

AUTOMATIC TRANSMISSION SERVICE
UNIT V

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

A. Provide student with objective sheet.

B. Provide student with information and job sheets.

C. Make transparencies.

D. Secure materials and equipment for job sheet demonstrations.

E. Discuss unit and specific objectives.

F. Discuss information sheet.

G. Demonstrate and discuss procedures outlined on the job sheets.

H. Give test.

I. Evaluate student performance on job sheets.

II. Unit references:

A. Crouse, William, and Anglin, Donald L. *Automotive Transmissions and Power Trains.* 5th ed. New York: McGraw-Hill Book Co., 1976.

B. Crouse, William H. *Automotive Mechanics.* 7th ed. New York: McGraw-Hill Book Co., 1975.

C. *Chevrolet Service Manual.* Detroit, Michigan: Chevrolet Motor Div./General Motors Corp., 1977.

D. *Chrysler, Plymouth, Dodge Chassis Service Manual.* Detroit, Michigan: Chrysler Corp., 1976.

E. *Ford Service Manual.* Dearborn, Michigan: Ford Motor Co., 1975-76.

F. *Automatic Transmissions: Theory and Design.* Detroit, Michigan: Chevrolet Motor Div./General Motors Corp., 1971.

G. *Automatic Transmission.* Instructor's Training Manual. Course Code 1701-006. Dearborn, Michigan: Ford Motor Co., 1977.

AUTOMATIC TRANSMISSION SERVICE
UNIT V

INFORMATION SHEET

I. Terms and definitions

   A. Transmission tune-up--Procedure involving the changing of fluid and filter and making all adjustments necessary for optimum transmission performance

   B. Band adjustment--Adjustment of band clearance to the drum while the band is not energized

   (NOTE: This adjustment is used mainly to time the band application with the release of another hydraulic component.)

   C. Throttle linkage or modulator valve adjustment--Act of setting proper shift points of the transmission to vehicle speed and load

   D. Selector adjustment--Procedure for assuring the correct positioning of the manually operated hydraulic valve for desired gear range

II. Repairs which can be performed with transmission in the vehicle

   A. Extension housing bushing and seal replacement

   B. Valve body assembly

   C. Speedometer, cable, and drive gear

   D. Servo (some models)

   E. Governor valve

   F. Vacuum modulator

   G. Oil pan, gasket, and filter

   H. Control linkage

III. Items to include in automatic transmission tune-up

   A. Change fluid

   B. Change filter or pick-up screen

   C. Clean oil pan

   D. Adjust bands, if adjustable

INFORMATION SHEET

E. Adjust selector linkage

F. Adjust neutral safety switch

G. Adjust throttle linkage or modulator valve, if possible

H. Check for fluid leaks

IV. Tests that are performed while transmission is in vehicle

A. Road test--Indicates overall characteristics of transmission operation

B. Stall test--Indicates the condition of torque converter operation and strength of hydraulic components

C. Fluid pressure test--Tests each hydraulic circuit and compares with a standard performance value, which indicates general problems in hydraulic components

D. Air pressure test--Tests each hydraulic component individually for pressure leaks

V. Types of automatic transmission fluids and their applications (Transparency 1)

A. Dexron and Dexron II

1. General Motors Corporation vehicles

2. Chrysler Corporation vehicles

3. American Motors Corporation vehicles

B. Prefix F--Ford motor vehicles

(NOTE: Some models of American Motors Corporation use Prefix F fluid also. A new Ford motor fluid has been placed in service in 1977 C-6 and later transmissions and should not be replaced with any other type of fluid. It has a distinctive orange color.)

VI. Procedure for properly checking transmission fluid level (Transparency 2)

A. Clean all dirt from around dipstick and cap

B. Operate engine until transmission fluid is at normal operating temperature

C. Shift transmission through all ranges at idle with brakes applied

INFORMATION SHEET

D. Leave engine idling in Park

E. Pull and wipe dipstick; reinsert until cap bottoms on tube

F. Pull dipstick and check if level is between arrows or Full and Add marks; adjust fluid level as necessary

(NOTE: Touch tip of dipstick to determine if fluid is at operating temperature. The dipstick should be too hot to hold.)

VII. Fluid conditions and possible transmission problems (Transparency 3)

A. Clean and deep red color--Normal condition

B. Burnt, discolored--Clutch or band burnt

C. Solid residue in fluid--Clutch or band has lost friction material

D. Varnish on dipstick--Coolant leak into transmission, engine overheating, or fluid broken down

VIII. Types of transmission filters (Transparency 4)

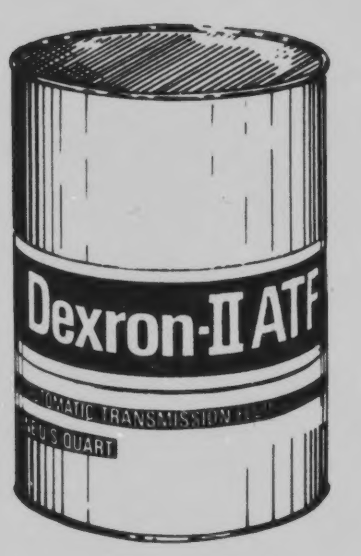
A. Fine-meshed screen

B. Paper

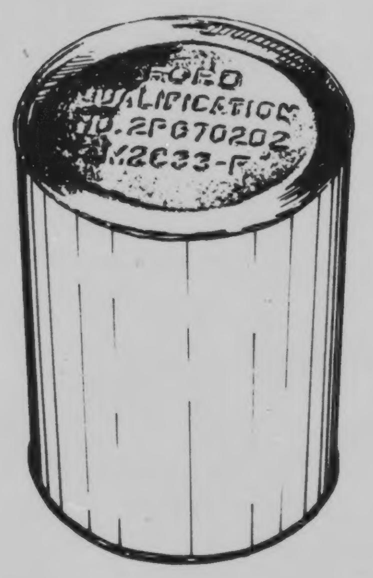
C. Dacron

Types of Automatic Transmission Fluid

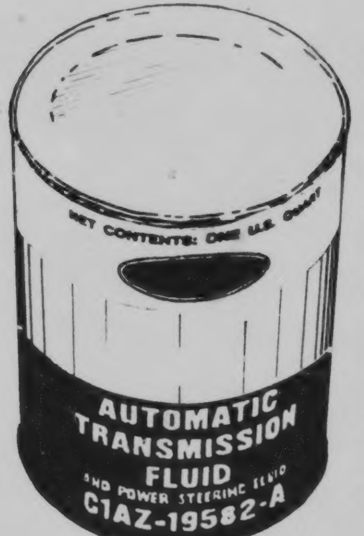
Dexron and Dexron II


Dexron-II ATF
TOMATIC TRANSMISSION FLU
E U.S QUART

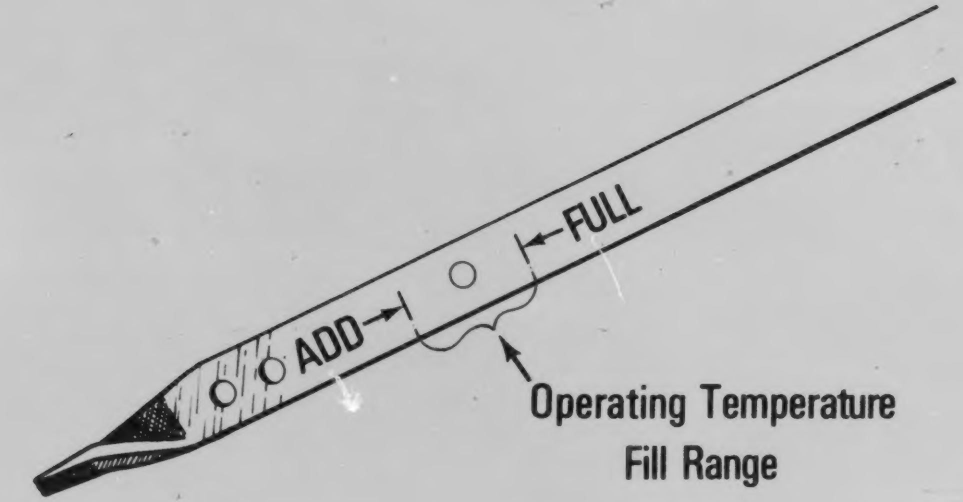
Prefix E


FORD
LIFICATION
D.2P070202
M2C33-F

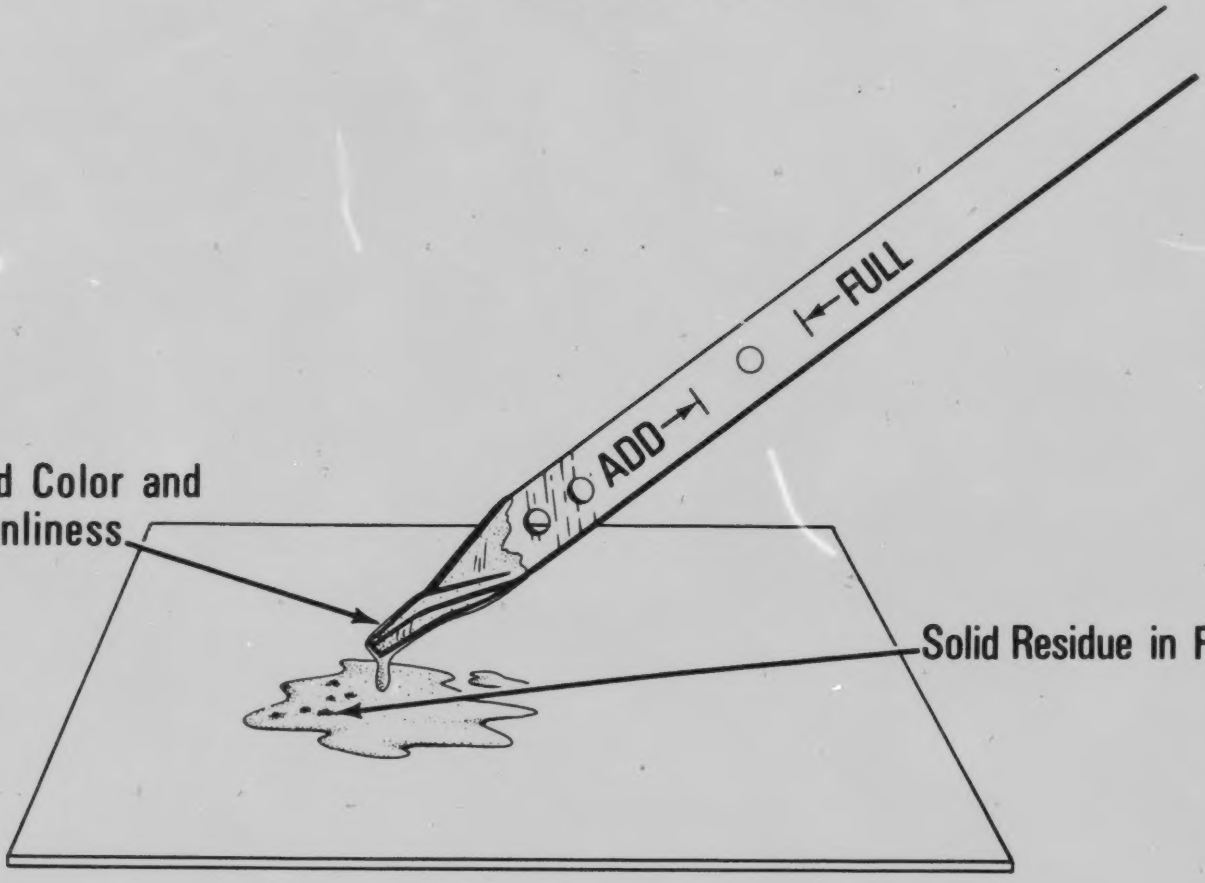
Ford Special Fluid


NET CONTENTS: ONE U.S. QUART
AUTOMATIC
TRANSMISSION
FLUID
AND POWER STEERING FLUID
C1AZ-19582-A

Checking Transmission Fluid Level

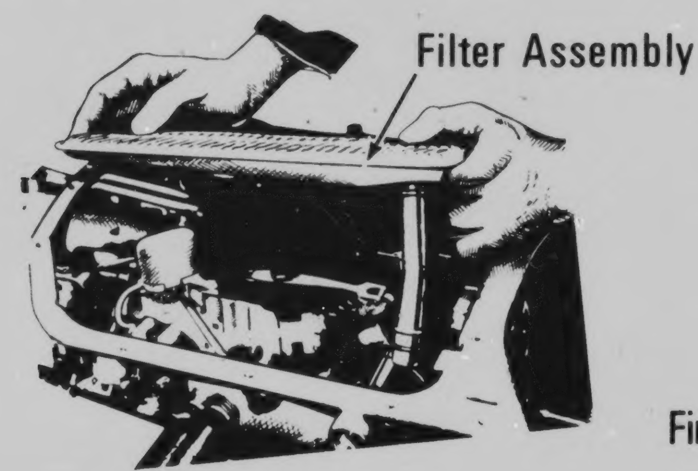

ADD
FULL
Operating Temperature Fill Range

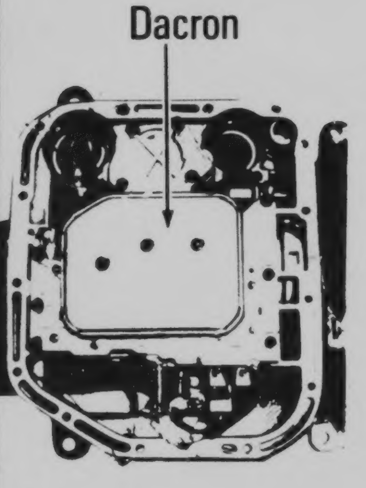
Fluid Conditions

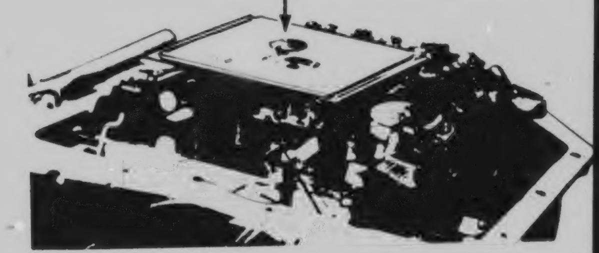

Fluid Color and Cleanliness
ADD
FULL
Solid Residue in Fluid

Types of Transmission Filters

Paper Element Enclosed in Metal Housing


Filter Assembly




Fine-Meshed Screen

AUTOMATIC TRANSMISSION SERVICE
UNIT V

JOB SHEET #1--PERFORM A ROAD TEST FOR TRANSMISSION DIAGNOSIS

I. Tools and equipment

   A. Seat covers

   B. Shop towels

   C. Service manual for vehicle being serviced

   D. Safety glasses

II. Procedure

   (NOTE: Check for proper engine performance before attempting a transmission road test.)

   A. Check vehicle tire pressure and adjust as necessary

   B. Check transmission fluid

      1. Check for proper level at operating temperature

      2. Check fluid color to see if it is clean and a normal red color

      3. Check fluid for a burnt odor

         (NOTE: Fluid discoloration and/or burnt smell indicates probable internal damage to transmission.)

   C. Cover front seat with clean seat covers

   D. Check neutral safety switch for proper operation while starting the engine

   E. Start the engine with gear shift selector in Park position

   F. Move the gear shift selector to Reverse position

      1. Note the quality of shift

      2. Note any noise such as a thump or grinding noise or buzzing noise

         (NOTE: A thump may indicate damaged motor mounts or too fast engine idle. A grinding noise may be caused by bad U-joints or damaged planetary gears. A buzzing noise could be a hydraulic valve "flutter" usually caused by dirty or aerated fluid.)

JOB SHEET #1

3. Hold the brake firmly and accelerate the engine moderately for just long enough to confirm that the transmission is not slipping

   (CAUTION: Check behind vehicle before accelerating the engine.)

G. Back out to the street

H. Shift from Reverse to Drive

1. Note the time it takes for the transmission to complete its shift

2. Look for a smooth, firm shift into drive

   (NOTE: It should shift quickly without excessive engine speedup between shifts. It should not have a harsh shift going into drive.)

I. Start off with light acceleration

1. Note speeds at which upshifts occur

2. Check for quality of shift

3. Check for slow shift or engine speedup between gears

J. Check passing gear operation at about 30 mph (48.28 km/h) and 45 mph (72.42 km/h)

(NOTE: At 30 mph [48.28 km/h] passing gear should shift back to low gear and only to second gear at 40 mph [64.37 km/h] on most models.)

K. Check shift in and out of passing for smooth, firm shift

L. Stop the vehicle and check for downshift that is barely noticeable

M. Return to the shop and compare road test information to the diagnosis chart for items of concern

DIAGNOSIS CHART

PROBLEM

CAR ROAD TEST

LEGEND
X PROBLEM AREA VS CAUSE
• @ O VACUUM ONLY
O BALLS/ #2/3/4 ONLY
L LOCKED
S STUCK

POSSIBLE CAUSE	ALL RANGES-SLIPS	DRIVE SLIPS-NO 1ST GEAR	LINE PRESSURE-ALL LOW	LINE PRESSURE-ALL HIGH	1-2 INTERM CL PRES HIGH	1-2 INTERM CL PRES LOW	2-3 DIRECT CL PRES HIGH	2-3 DIRECT CL PRES LOW	NO 1-2 UPSHIFT	1-2 U.S. EARLY/LATE	1-2 UPSHIFT @ W.O.T. ONLY	SLIPS 1-2 UPSHIFT	ROUGH 1-2 UPSHIFT	NO 2-3 UPSHIFT	2-3 U.S. EARLY/LATE	SLIPS 2-3 UPSHIFT	ROUGH 2-3 UPSHIFT	NO WOT 1-2 UPSHIFT	NO-PART TH DOWN SHIFT	NO-FULL TH DOWN SHIFT	2-3 UPSHIFT-W.O.T. ONLY	HARSH-DOWN SHIFT	L1 RANGE-NO ENG BRAKING	L2 RANGE-NO ENG BRAKING	NEUTRAL-DRIVES IN NEUTRAL	REVERSE-NO REVERSE	SLIPS IN REVERSE	PARK-NO PARK-RATCHETS	NOISY-ALL RANGES	1-2 2-3 SHIFT NOISY	REV & D L1 & L2 NOISY	LOW COOLER-FLOW	SPEWS OIL OUT BREATHER	HUNTS BETWEEN 2 & 3 AND 3 & 2
LOW OIL LEVEL/WATER IN OIL	x	x	x			x		x				x				x											x		x	x		x	x	
VACUUM LEAK				x	x		x		x	x	x		x		x		x				x													
MODULATOR &/OR VALVE	x	x	•	x	x							x	x		x	x	x										x							
STRAINER &/OR GASKET	x	x	x			x		x																			x		x			x	x	
GOVERNOR-VALVE/SCREEN			x	x					x	x					x																			
VALVE BODY-GASKET/PLATE	x	x	x			x		x	x	x		x		x	x	x											x		x					
PRES REG &/OR BOOST VALVE	x	x	x	x	x	x	x	x	x			x	x			x	x						x	x		x	x							
BALL (#1) SHY	x	x	•			x				x		x			x	x						O				x	x							
1-2 SHIFT VALVE						x			x	x	x	x											x				x							
2-3 SHIFT VALVE								x						x	x	x	x		x															
MANUAL LOW CONT'L VALVE																							x											
DETENT VALVE & LINKAGE				x							x				x				x	x	x													S
DETENT REG VALVE																		x																
2-3 ACCUMULATOR						x						x					x																	
MANUAL VALVE/LINKAGE	x	x	x																				x	x		x	x							
POROSITY/CROSS LEAK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x					x	x		x	x							
PUMP-GEARS	x	x	x			x		x				x				x													x					
PRIMING VALVE SHY	x	x	x																														S	
COOLER VALVE LEAK																																x	x	
CLUTCH SEAL RINGS	x	x	x			x		x	x			x		x		x							x	x		x	x							
POROUS/CROSS LEAK	x	x	x			x		x	x			x	x	x		x		x								x	x					x	x	
GASKET SCREEN-PRESSURE	x	x	x																							x	x		x			x		
BAND-INTERM O.R																								x										
CASE-POROUS/X LEAK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x						x			x	x					x		
1-2 ACCUMULATOR	x	x	x			x			x			x	x																					
INTERMED SERVO		x	x			x						x												x										
FORWARD CLUTCH ASS'Y		x																					x	x	x	L								
DIRECT CLUTCH ASS'Y								x						x		x										x	x			x				
INTERMED CL ASS'Y						x			x			x																		x				
L & REV CL ASS'Y																							x			x	x							
INT ROLLER CL ASS'Y									x			x												x										
L & R ROLLER CL ASS'Y		x																																
PARK PAWL/LINKAGE																												x						
CONVERTER ASS'Y																													x		x			
GEAR SET & BEARINGS																													x	x				

AUTOMATIC TRANSMISSION SERVICE
UNIT V

JOB SHEET #2--REPLACE AN EXTENSION HOUSING BUSHING AND SEAL

I. Tools and equipment

   A. Basic hand tool set

   B. Seal puller

   C. Seal driver

   D. Bushing puller

   E. Bushing driver

   F. Jack stands, 4

   G. Floor jack

   H. Drain pan

   I. Nonhardening sealer

II. Procedure

   A. Raise vehicle and support securely on jack stands

   B. Mark the rear U-joint and pinion flange

   C. Position the drain pan under the transmission extension housing

   D. Remove the propeller shaft

   E. Check condition of bearing surface on slip joint

   F. Pull the extension housing seal (Figure 1)

   G. Pull the extension housing bushing (Figure 1)

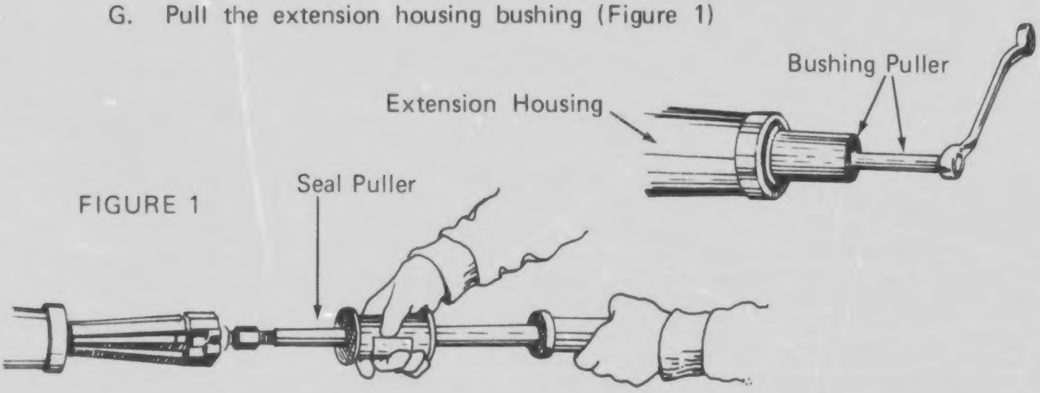


FIGURE 1

JOB SHEET #2

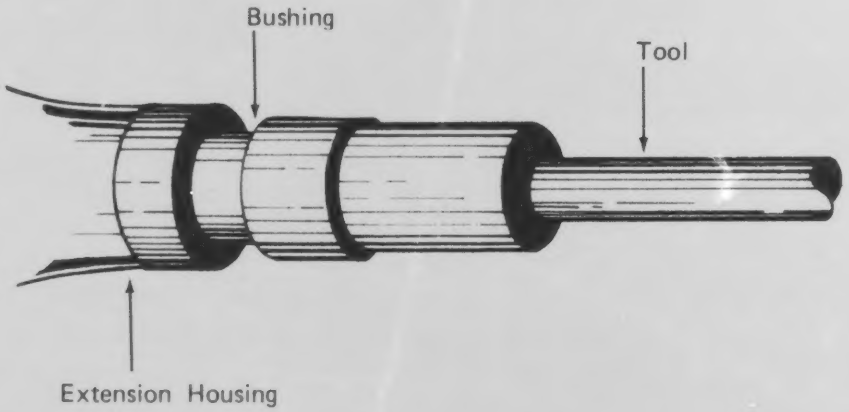
H. Clean housing seal seat and bushing area

I. Install housing bushing using the appropriate driver (Figure 2)

  1. Place bushing on driver
  2. Align the bushing and driver over the output shaft with the housing
  3. Drive the bushing to the proper depth

     (NOTE: If the correct driver is used, the driver will bottom when the bushing is at the proper depth.)

FIGURE 2



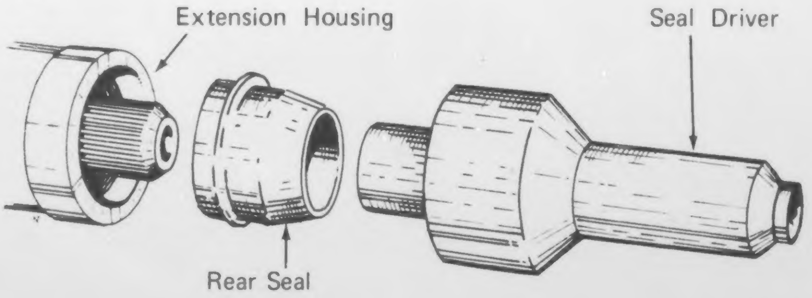
J. Install seal (Figure 3)

  1. Apply sealer to the outside of the new seal
  2. Align seal on the extension housing seal seat area

JOB SHEET #2

3. Drive seal into place with seal driver

FIGURE 3


Extension Housing
Seal Driver
Rear Seal

K. Lubricate seal lip

L. Install propeller shaft into transmission output shaft

M. Connect propeller shaft to pinion flange while aligning the marks previously made

N. Torque U-joint attaching bolts

O. Lower vehicle to floor

P. Start engine

Q. Check fluid level

R. Check for fluid leak at the new seal

AUTOMATIC TRANSMISSION SERVICE
UNIT V

JOB SHEET #3--TUNE-UP AN AUTOMATIC TRANSMISSION

I. Tools and materials

- A. Basic hand tool set
- B. Jack stands, 4
- C. Floor jack
- D. Large drain pan
- E. Creeper
- F. Safety glasses
- G. Transmission fluid
- H. Transmission filter package
- I. Transmission funnel

II. Procedure

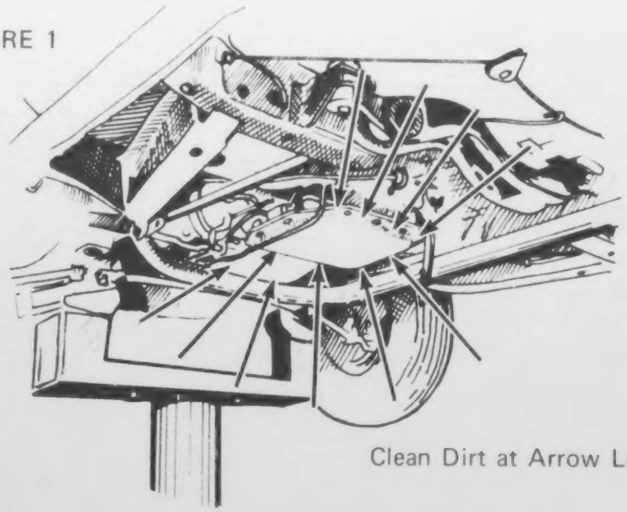
(NOTE: The exact procedure for the following tune-up activities should be followed in the service manual for the particular vehicle. Most of the procedures below are general statements; exact procedures will vary from vehicle to vehicle.)

- A. Road test the vehicle before servicing to check for conditions that the owner may not have mentioned
- B. Raise the vehicle and secure on jack stands

JOB SHEET #3

C. Clean dirt and grease from around the transmission oil pan and torque converter inspection cover (Figure 1)

FIGURE 1



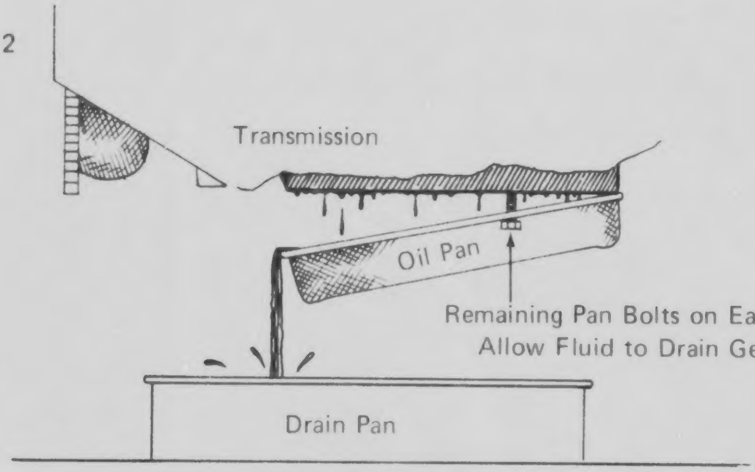
Clean Dirt at Arrow Locations

D. Drain transmission fluid

(NOTE: Follow this procedure when the oil pan does not have a drain plug.)

1. Place large drain pan under the transmission oil pan
2. Remove all pan bolts except one on each side of the pan (Figure 2)
3. Loosen the two remaining bolts approximately two turns
4. Pry the pan loose with a screwdriver to begin draining (Figure 2)

FIGURE 2



Remaining Pan Bolts on Each Side
Allow Fluid to Drain Gently

JOB SHEET #3

5. Hold the oil pan with one hand while removing the bolts with the other hand

6. Pour the remaining fluid gently into the drain pan

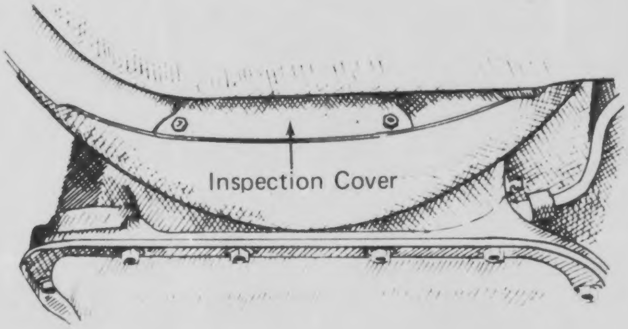
   (NOTE: Check for metal or fiber deposits in the bottom of the oil pan that may indicate the need for further service.)

E. Drain the torque converter

(NOTE: Some torque converters do not have drain plugs; therefore, this step may be omitted.)

1. Remove the torque converter inspection cover (Figure 3)

FIGURE 3

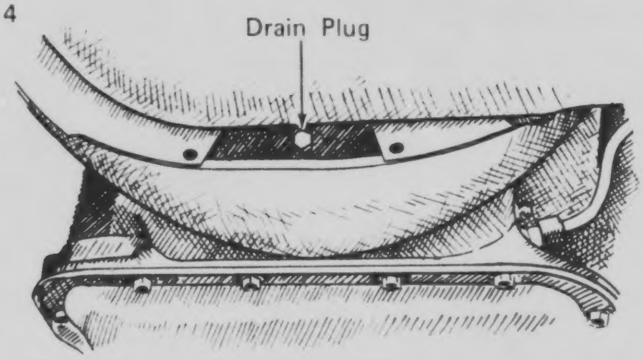


2. Turn engine slowly while watching for converter drain plug (Figure 4)

JOB SHEET #3

3. Position the drain plug to bottom (Figure 4)

FIGURE 4



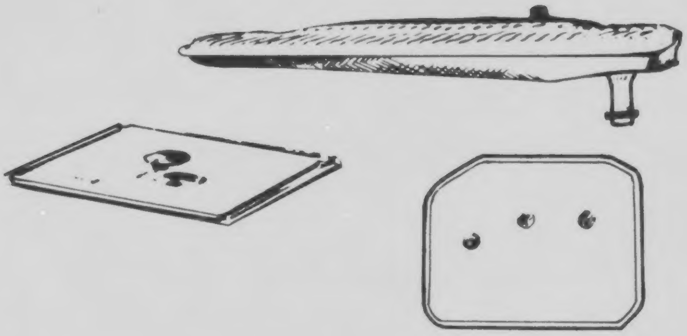
4. Place drain pan under converter plug area

5. Remove drain plug

6. Replace the plug when converter has completely drained

F. Remove the transmission filter element (Figure 5)

FIGURE 5



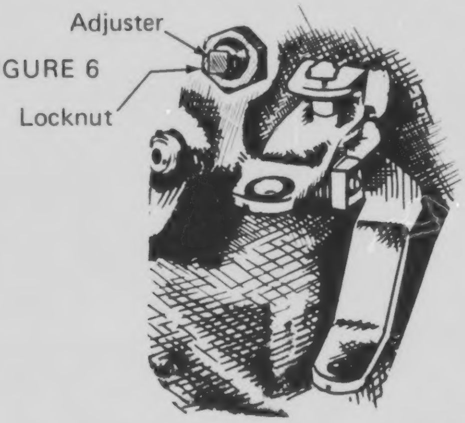
JOB SHEET #3

G. Adjust bands

(NOTE: On some models of transmissions, the bands are not adjustable. On other models, the adjusters may be located either inside or outside the case.)

1. Locate the band adjuster
2. Obtain the correct specifications from manufacturer's service manual for each band being adjusted
3. Loosen adjuster locknut approximately five turns while holding the adjuster screw (Figure 6)

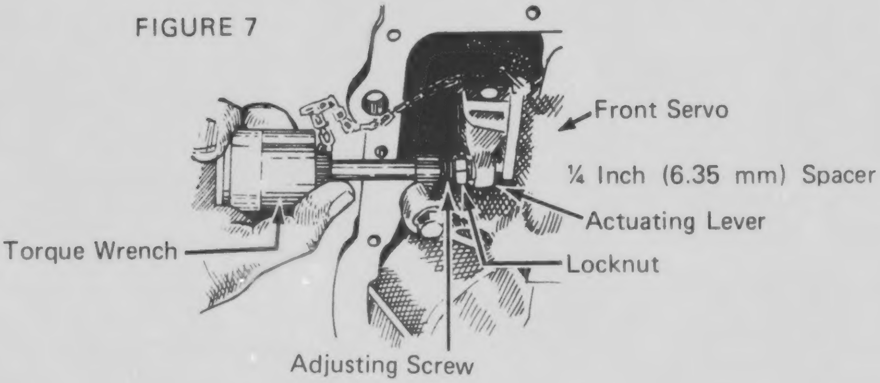
FIGURE 6


Adjuster
Locknut

4. Tighten the adjuster to the specified torque

   (NOTE: On some models a spacer block should be placed between servo piston push rod and adjuster. See Figure 7.)

FIGURE 7


Front Servo
¼ Inch (6.35 mm) Spacer
Actuating Lever
Torque Wrench
Locknut
Adjusting Screw

JOB SHEET #3

5. Back the adjuster off the exact number of turns as specified

6. Torque the adjuster locknut while holding the adjuster from turning

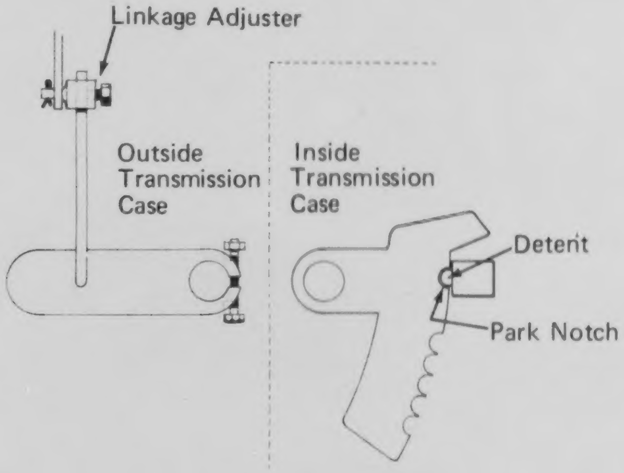
H. Adjust the shift control lever

1. Place the selector lever in Park position

2. Loosen linkage adjusting link

3. Check to see that the shift detent on the valve body inside the transmission is sitting in the bottom of the detent notch for Park (Figure 8)

FIGURE 8


Linkage Adjuster
Outside Transmission Case
Inside Transmission Case
Detent
Park Notch

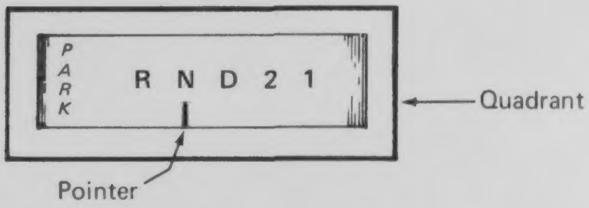
4. Tighten the linkage adjuster lock

I. Adjust the shift quadrant pointer

1. Move the shift lever to Neutral position

2. Adjust the quadrant pointer to read exactly on **N** (Figure 9)

FIGURE 9


P A R K
R N D 2 1
Quadrant
Pointer

JOB SHEET #3

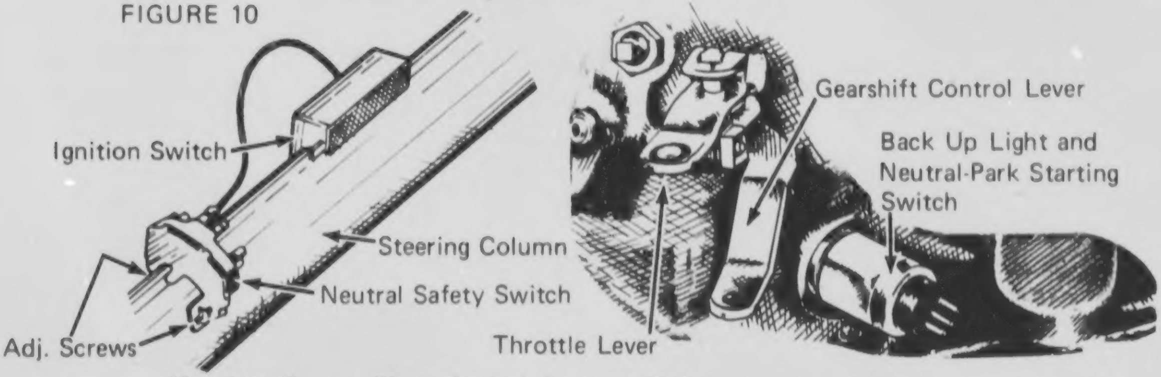
J. Adjust the neutral safety switch

(NOTE: When adjustment is completed, the engine should crank in both Park and N but not in any other position.)

1. Place the shift control lever in Neutral position

2. Adjust the neutral safety switch in either direction until correctly adjusted (Figure 10)

FIGURE 10


Ignition Switch
Steering Column
Neutral Safety Switch
Adj. Screws
Gearshift Control Lever
Back Up Light and Neutral-Park Starting Switch
Throttle Lever

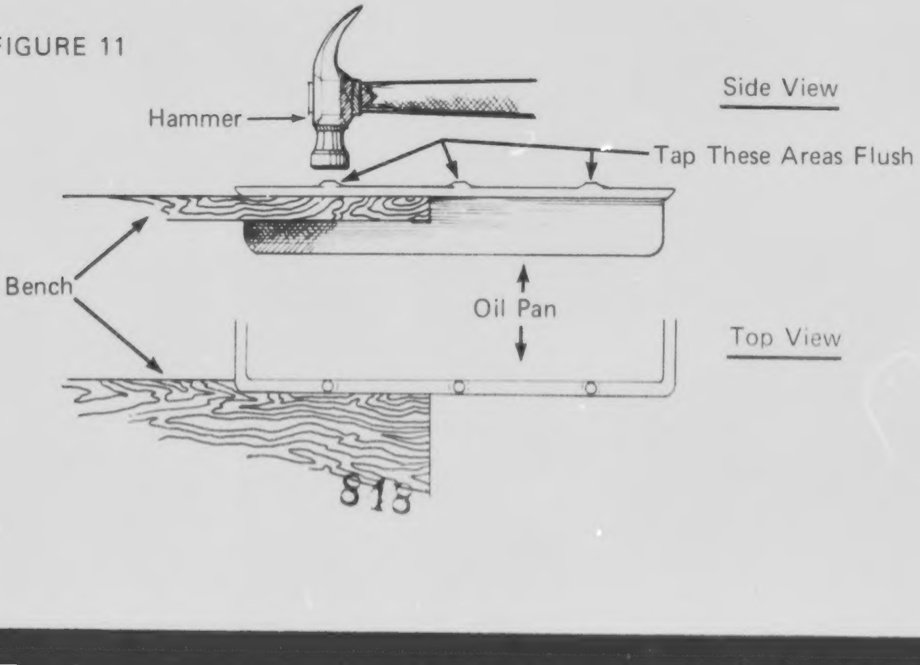
K. Install new filter element in transmission

L. Replace oil pan

1. Clean the old pan gasket from the pan and transmission case mating surfaces

2. Straighten the pan bolt hole area by laying the pan rim on the edge of workbench and tapping the hole area down evenly with a hammer (Figure 11)

FIGURE 11


Side View
Hammer
Tap These Areas Flush
Bench
Oil Pan
Top View

JOB SHEET #3

3. Wash the pan clean in solvent

4. Apply a light coat of nonhardening sealer to pan mating surface

5. Place gasket on pan mating surface

6. Attach oil pan to the transmission case

   (NOTE: Start all pan bolts before tightening.)

7. Tighten all pan bolts very lightly

8. Retighten to specified torque

   (CAUTION: Use care not to mash gasket while tightening pan bolts.)

M. Lower vehicle to the floor, maintaining rear wheel at approximately four inches off the floor

N. Adjust throttle linkage if so equipped

(NOTE: Refer to the service manual for the particular vehicle for proper adjustment procedures.)

O. Fill transmission with fluid

(NOTE: Refer to manufacturer's specifications for fluid type and transmission capacity.)

1. Pour four quarts of fluid in the transmission filler tube on full size vehicles and three quarts in compact vehicles

2. Start engine and place shift lever in Neutral position

   (NOTE: On vehicles with the torque converter drained, three to four more quarts of fluid may have to be added. On vehicles without a torque converter drain, the fluid level should be close to full.)

3. Add fluid until it is to the Add line on the dip stick

4. Operate the engine until the transmission fluid is at operating temperature, approximately 15 minutes

5. Add fluid to the Full mark on the dipstick

   (CAUTION: Do not overfill the transmission. It is usually better to be slightly below the Full mark than to be over the mark.)

JOB SHEET #3

P. Turn off engine

Q. Lower the rear wheels to the floor

R. Road test the vehicle for proper operation

S. Check for fluid leaks

AUTOMATIC TRANSMISSION SERVICE
UNIT V

TEST

NAME ______________________________ SCORE ______________

1. Match the terms on the right to the correct definitions.

_____a. Procedure for assuring the correct positioning of the manually operated hydraulic valve for desired gear range

_____b. Adjustment of band clearance to the drum while the band is not energized

_____c. Act of setting proper shift points of the transmission to vehicle speed and load

_____d. Procedure involving the changing of fluid and filter and making all adjustments necessary for optimum transmission performance

1. Transmission tune-up
2. Band adjustment
3. Throttle linkage or modulator valve adjustment
4. Selector adjustment

2. Select from the list below the repairs which can be performed with the transmission in the vehicle. Place an "X" in the appropriate blanks.

_____a. Extension housing bushing and seal replacement

_____b. Band

_____c. Control linkage

_____d. Vacuum modulator

_____e. Oil pan, gasket, and filter

_____f. Clutch

_____g. Valve body assembly

_____h. Governor valve

_____i. Servo

_____j. Speedometer, cable, and drive gear

3. Select from the list below the items to include in an automatic transmission tune-up.

______a. Adjust bands, if adjustable

______b. Change filter or pick-up screen

______c. Adjust selector linkage

______d. Replace servo seals

______e. Check for fluid leaks

______f. Clean oil pan

______g. Change fluid

______h. Adjust neutral safety switch

______i. Adjust clutch piston

______j. Adjust throttle linkage or modulator valve, if possible

4. Match the tests on the right to the correct purposes.

______a. Tests each hydraulic component individually for pressure leaks

______b. Indicates overall characteristics of transmission operation

______c. Tests each hydraulic circuit and compares with a standard performance value, which indicates general problems in hydraulic components

______d. Indicates the condition of torque converter operation and strength of hydraulic components

1. Road test
2. Stall test
3. Fluid pressure test
4. Air pressure test

5. Distinguish between the types of automatic transmission fluids by placing a "D" in front of the uses of Dexron or Dexron II and an "F" in front of the uses of Prefix F.

______a. American Motors Corporation vehicles

______b. Chrysler Corporation vehicles

______c. Ford Motor vehicles

______d. General Motors Corporation vehicles

6. Arrange in order the following procedure for checking automatic transmission fluid level.

   ______a. Leave engine idling in Park

   ______b. Pull dipstick and check if level is between arrows or Full and Add marks; adjust fluid level as necessary

   ______c. Clean all dirt from around dipstick and cap

   ______d. Pull and wipe dipstick; reinsert until cap bottoms on tube

   ______e. Shift transmission through all ranges at idle with brakes applied

   ______f. Operate engine until transmission fluid is at normal operating temperature

7. Match the fluid conditions on the right to the possible transmission problems.

   ______a. Clutch or band burnt

   ______b. Clutch or band has lost friction material

   ______c. Normal

   ______d. Coolant leak into transmission, engine overheating, or fluid broken down

   1. Clean and deep red color

   2. Varnish on dipstick

   3. Burnt, discolored

   4. Solid residue in fluid

8. List three types of transmission filters.

   a. ____

   b. ____

   c. ____

9. Demonstrate the ability to:

   a. Perform a road test for transmission diagnosis.

   b. Replace an extension housing bushing and seal.

   c. Tune-up an automatic transmission.

   (NOTE: If the above activities have not been accomplished prior to the test, ask the instructor when they should be completed.)

AUTOMATIC TRANSMISSION SERVICE
UNIT V

ANSWERS TO TEST

1. a. 4
   b. 2
   c. 3
   d. 1
2. a, c, d, e, g, h, i, j
3. a, b, c, e, f, g, h, j
4. a. 4
   b. 1
   c. 3
   d. 2
5. a. D
   b. D
   c. F
   d. D
6. a. 4 f. 2
   b. 6
   c. 1
   d. 5
   e. 3
7. a. 3
   b. 4
   c. 1
   d. 2

8. a. Fine-meshed screen

   b. Paper

   c. Dacron

9. Performance skills evaluated to the satisfaction of the instructor

85.p.

AIR CONDITIONING
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to service an automotive air conditioning system. The student should be able to use air conditioning service equipment and purge, repair, evacuate, leak test, and charge the system. This knowledge will be evidenced through demonstration and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with the air conditioning system to the correct definitions.
2. Identify the components of the refrigeration system.
3. Identify the high and low sides of a compressor.
4. List safety rules for auto air conditioning.
5. Discuss the function of a receiver-drier (dehydrator).
6. Identify the back seat, midposition, and front seat of a service valve.
7. Identify components of a manifold gauge set.
8. Demonstrate the ability to:
   a. Connect manifold gauge set into system.
   b. Purge the system.
   c. Replace condenser.
   d. Evacuate the system using a vacuum pump or charging station.
   e. Leak test the system using a halide leak detector.
   f. Charge the air-conditioning system using pound cans.
   g. Remove and replace compressor crankshaft seal.

AIR CONDITIONING
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information and job sheets.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information sheet.

  F. Demonstrate and discuss procedures outlined on the job sheets.

  G. Give test.

II. Unit references:

  A. *How Air Conditioning Works.* Ford Training Handbook Course 19000. vol. 65 S7L2. March 1965.

  B. Seymour, A. T.; Wright, J. R.; and Conaster, William Dean. *Automotive Air Conditioning Theory and Basic Service.* San Diego, California: National Automotive Service, Inc., 1970.

  C. *Air Conditioning Instruction Manual.* Lockport, New York: Harrison Radiator Div./General Motors Corp., 1972.

  D. *Chevrolet Service Manual.* Detroit: Chevrolet Motor Div./General Motors Corp., 1977.

  E. *Chrysler, Plymouth, Dodge Chassis Service Manual.* Detroit: Chrysler Corp., 1976.

  F. *Ford Service Manual.* Dearborn, Michigan: Ford Motor Co., 1975.

AIR CONDITIONING
UNIT I

INFORMATION SHEET

I. Terms and definitions (Transparencies 1-21)

A. Air-conditioner--Device used to control temperature, humidity, and air movement (Transparency 1)

B. Plenum blower assembly--Housing on the fire wall inside the engine compartment containing air ducts, air valves, and blower

C. Air inlet valve--Adjustable door in the plenum blower assembly that permits selection of outside and inside air for heating and cooling systems

D. Ambient air temperature--Temperature of air surrounding an air-conditioned unit, such as a vehicle or building

E. Ambient compressor switch--Outside air sensing switch used to control compressor clutch operation and prevent compressor operation at low temperatures when air conditioning is not required

F. Back seating--Act of turning the service valve stem all the way counterclockwise until the valve is seated

(NOTE: In this position, the valve outlet to the system is open and the service port in the valve is closed. This is its normal operating position.)

G. Blower fan--Motor-driven fan used to force air through the evaporator and to circulate the cooled air through the passenger compartment of the automobile

H. Boiling point--Temperature at which a liquid changes to a vapor

I. Can valve--Mechanical device used to pierce, dispense, and seal small cans of refrigerant

J. Charge--Specific amount of refrigerant or oil by volume or weight

K. Charging--Act of placing a charge of refrigerant or oil into the air conditioning system

L. Compound gauge--Gauge that will register both pressure and vacuum; used on the low side of the system

INFORMATION SHEET

M. Compressor--Component of the refrigeration system that pumps refrigerant vapor and increases the pressure of the refrigerant (Transparency 5)

N. Compressor shaft seal--Assembly mounted on the compressor crankshaft permitting the shaft to be turned without loss of refrigerant or oil

O. Condensation--Act of changing a vapor to a liquid

P. Condenser--Component of a refrigeration system in which refrigerant vapor is changed to a liquid by the removal of heat

Q. Contaminant--Substance other than refrigerant and refrigeration oil in the system

R. Desiccant--Drying agent used in refrigeration systems to remove excess moisture

S. Discharge--To bleed some or all of the refrigerant from a system by opening a valve or connection and permitting the refrigerant to escape slowly

T. Discharge line--Hose that connects the compressor outlet to the condenser inlet

U. Discharge side--That portion of the refrigeration system under high pressure, extending from the compressor outlet to the thermostatic expansion valve inlet

V. Drier--Device containing desiccant placed in the liquid line to absorb moisture in the system

(NOTE: This is ordinarily combined with the receiver.)

W. Evacuate--To create a vacuum within a system to remove all traces of air and moisture

X. Evaporator--Component of an air conditioning system in which refrigerant liquid is changed into a vapor by removing heat from the air which is then discharged into the passenger compartment

Y. Celsius--Thermometer scale using 0° as the freezing point of water and 100° as the boiling point of water

(NOTE: The Celsius scale is replacing the previously used Fahrenheit scale.)

Z. Filter--Device used with the drier or as a separate unit to remove foreign solid material from the refrigerant

INFORMATION SHEET

AA. Flooding--Condition caused by too much liquid refrigerant being metered into the evaporator

(NOTE: This condition is detected by ice on the suction line.)

BB. Flush--To remove solid particles such as metal flakes or dirt from refrigerant passages

CC. Foaming--Formation of a froth of the oil and refrigerant due to rapid boiling out of the refrigerant dissolved in the oil when the pressure is suddenly reduced

(NOTE: Foam in the sight glass is an indication of a very low refrigerant level.)

DD. Freeze-up--Failure of a unit to operate properly due to the formation of ice at the expansion valve orifice or on the evaporator coils or fins

EE. Front seating--Act of closing compressor service valves by turning them all the way clockwise

(NOTE: This position is used only to isolate the compressor. The compressor is never operated with valves in this position.)

FF. Head pressure--Pressure of the refrigerant from the discharge reed valve through lines and condenser to the expansion valve orifice

GG. High side service valve--Device located on the discharge side of the compressor to allow the technician to check high side pressure and perform other necessary operations

HH. High suction pressure--Low side pressure higher than normal due to a malfunction of the system

II. Insulate--To isolate or seal off with a nonconductor

JJ. Leak detector--Any device used to detect leaks in an air-conditioning system

(NOTE: A dye solution, electronic tester unit, or halide torch could be used.)

KK. Liquid line--Line connecting the drier outlet with the expansion valve inlet

(NOTE: The line from the condenser outlet to the drier inlet is sometimes referred to as a liquid line also.)

INFORMATION SHEET

LL. Low head pressure--High side pressure lower than normal due to a malfunction of the system

MM. Low side service valve--Device located on the suction side of the compressor to allow the technician to check low side pressure or perform other necessary service operations

NN. Low suction pressure--Pressure lower than normal in the suction side of the system due to a malfunction of the unit

OO. Magnetic clutch--Coupling device used to turn the compressor on and off electrically

PP. Overcharge--Indication of too much refrigerant or refrigeration oil in the system

QQ. Pressure--Force per unit of area; pressure of refrigerant is measured in pounds per square inch (psi) or kilopascals (kPa)

RR. Pressure drop--Difference in pressure between any two points that may be caused by a restriction or friction

SS. Purge--To remove moisture and air from a system or a component by flushing with a dry gas refrigerant

TT. Ram air--Air that is forced through the condenser coils by the movement of the vehicle or action of the fan

UU. Receiver-Drier--Combination container for the storage of liquid refrigerant and desiccant

VV. Reciprocating compressor--Positive displacement compressor with pistons that travel back and forth in a cylinder (Transparency 5)

WW. Reed valves--Thin leaves of steel located in the valve plate of automotive compressors to act as suction and discharge valves

(NOTE: The suction valve is located on the bottom of the valve plate and the discharge valve is located on top.)

XX. Refrigerant-12 (R-12)--Refrigerant used in automotive air conditioners (Transparency 2)

YY. Refrigeration cycle--Complete circulation of refrigerant through an air-conditioning system accompanied by changes in temperature and pressure, such as changes of state from vapor to liquid to vapor

ZZ. Refrigeration oil--Highly refined oil free from all contaminants, such as sulfur, moisture, and tars

INFORMATION SHEET

AAA. Remote bulb--Sensing device connected to the expansion valve by a capillary tube to sense temperature and transmit pressure to the expansion valve for its proper operation

BBB. Schrader valve--Spring-loaded valve similar to a tire valve located inside the service valve fitting and used on some control devices to hold refrigerant in the system

(NOTE: Special adapters must be used with the gauge hose to allow access to the system.)

CCC. Service port--Fittings located on the service valves and on some control devices to connect manifold gauge set charging hoses to air-conditioning system

DDD. Short cycling--Condition caused by poor air circulation or a thermostat out of adjustment causing the air-conditioning unit to run for very short periods

EEE. Suction line--Line connecting the evaporator outlet to the compressor inlet

FFF. Suction side--That portion of the refrigeration system under low pressure extending from the expansion valve outlet to the compressor inlet

GGG. Suction throttling valve (STV, POA, and EPA valves)--Back pressure regulated device that prevents evaporator core freeze-up

HHH. Suction pressure--Compressor inlet pressure which reflects the pressure of the system on the low side

III. Thermostatic switch- Temperature-sensitive switch used to control the compressor clutch and cycle the compressor as a means of temperature control in an air-conditioning system

(NOTE: Switches are bellows or bimetal types.)

JJJ. Undercharge--System short of refrigerant which will result in improper cooling

KKK. Vacuum--Less than atmospheric pressure; expressed in inches of mercury

LLL. Vacuum pump--Mechanical device used to evacuate the refrigeration system to rid it of excess moisture and air

MMM. Vapor--Gas; gaseous state of refrigerant

INFORMATION SHEET

II. Components of the refrigeration system (Transparency 3)

  A. High side

    1. Discharge side of compressor and its high side service fitting

    2. Condenser

    3. Receiver-Drier

    4. Inlet half of expansion valve

    5. Connecting hoses

  B. Low side

    1. Suction side of compressor and its low side service fitting

    2. Evaporator

    3. Outlet half of expansion valve

    4. Connecting hoses

III. Location of high and low sides of a compressor (Transparency 4)

  A. High side--Discharge side of the compressor

  B. Low side--Suction side of the compressor

IV. Safety rules for auto air conditioning

  A. Do not inhale fumes from burned fluorocarbon gases

  (NOTE: Fluorocarbon gases are highly poisonous.)

  B. Do not warm a refrigerant can over 125°F (51°C)

  C. Do not abuse a refrigerant container

  D. Do not allow high side pressure to enter refrigerant container

  E. Wear safety glasses and a full face shield or sealed goggles while working on an air-conditioning system

  F. Do not apply torch to a pressurized system

  G. Inspect all pressure hoses, gauges, and connections before using

INFORMATION SHEET

H. Ventilate a gas-filled area before working there

I. Do not pump liquid refrigerant into a compressor

(NOTE: If liquid refrigerant is pumped into compressor, it will cause severe damage to the compressor.)

V. Function of receiver-drier (dehydrator)--To provide storage of liquid refrigerant and to absorb moisture in the system

VI. Valve positions (Transparency 14)

A. Front seat

(NOTE: Front seat is the shut-off position to isolate compressor from the system.)

(CAUTION: The air-conditioner must never be operated with the service valves front seated. This would damage the compressor because no refrigerant would be flowing through compressor and excessive head pressures would build up, causing seals to blow out.)

B. Midposition

(NOTE: Midposition is the test position to connect service gauge port into system so that gauge readings may be taken while system is operating. Midposition is sometimes referred to as *cracking the valve*.)

C. Back seat

(NOTE: Back seat is the normal operating position to seal off service gauge port.)

VII. Components of a manifold gauge set (Transparency 15)

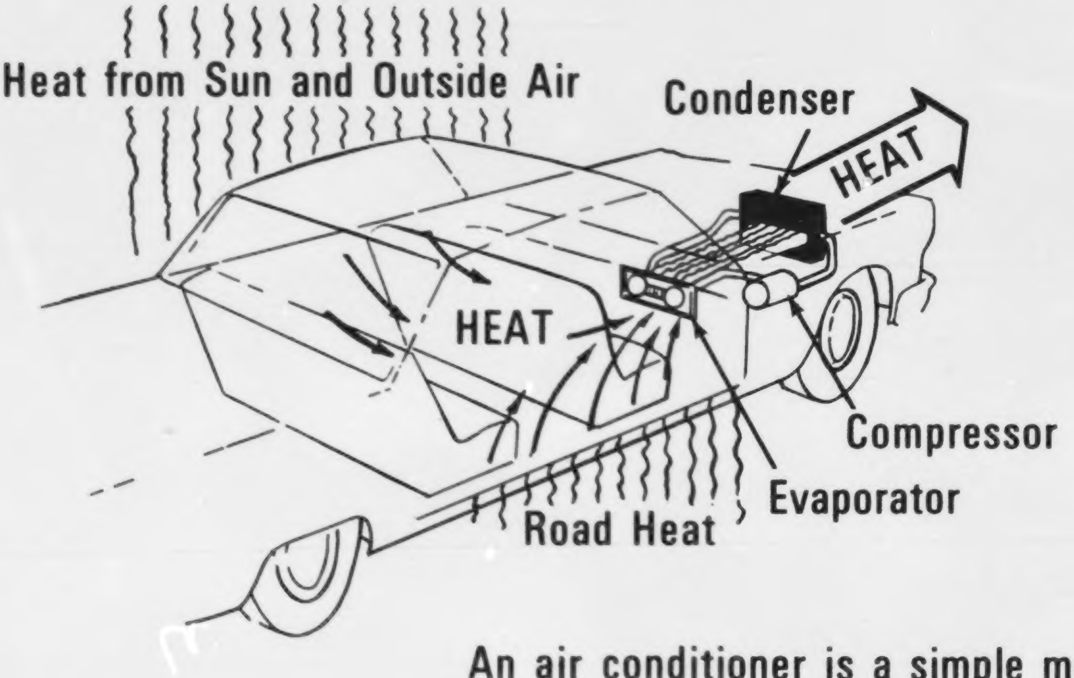
A. High pressure side

1. High side gauge
2. Manifold
3. High side hand valve
4. High side test hose

B. Low pressure side

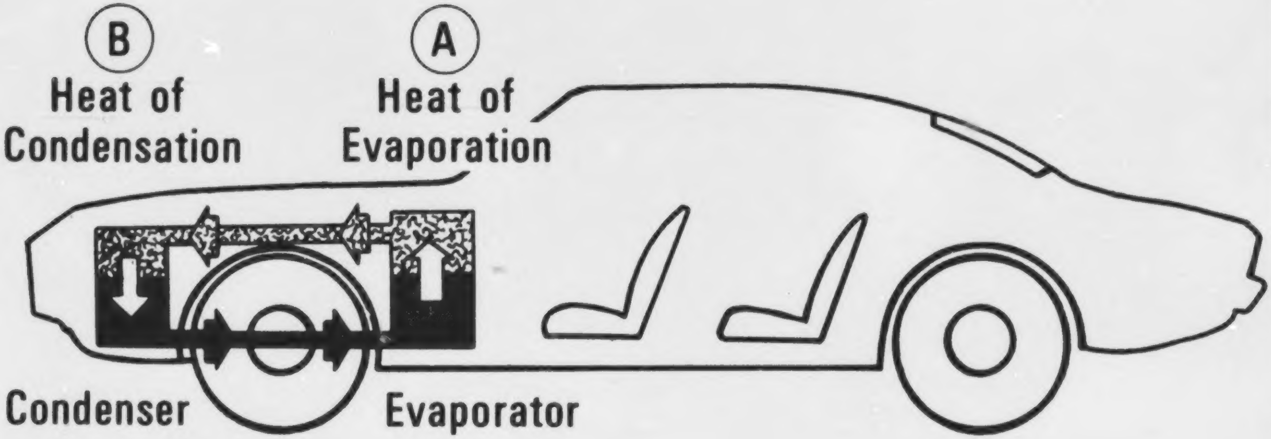
1. Low side gauge
2. Manifold
3. Low side hand valve
4. Low side test hose

What an Air Conditioner Does


Heat from Sun and Outside Air
Condenser
HEAT
HEAT
Compressor
Evaporator
Road Heat

An air conditioner is a simple mechanical device to move heat from the inside of the car to the outside.

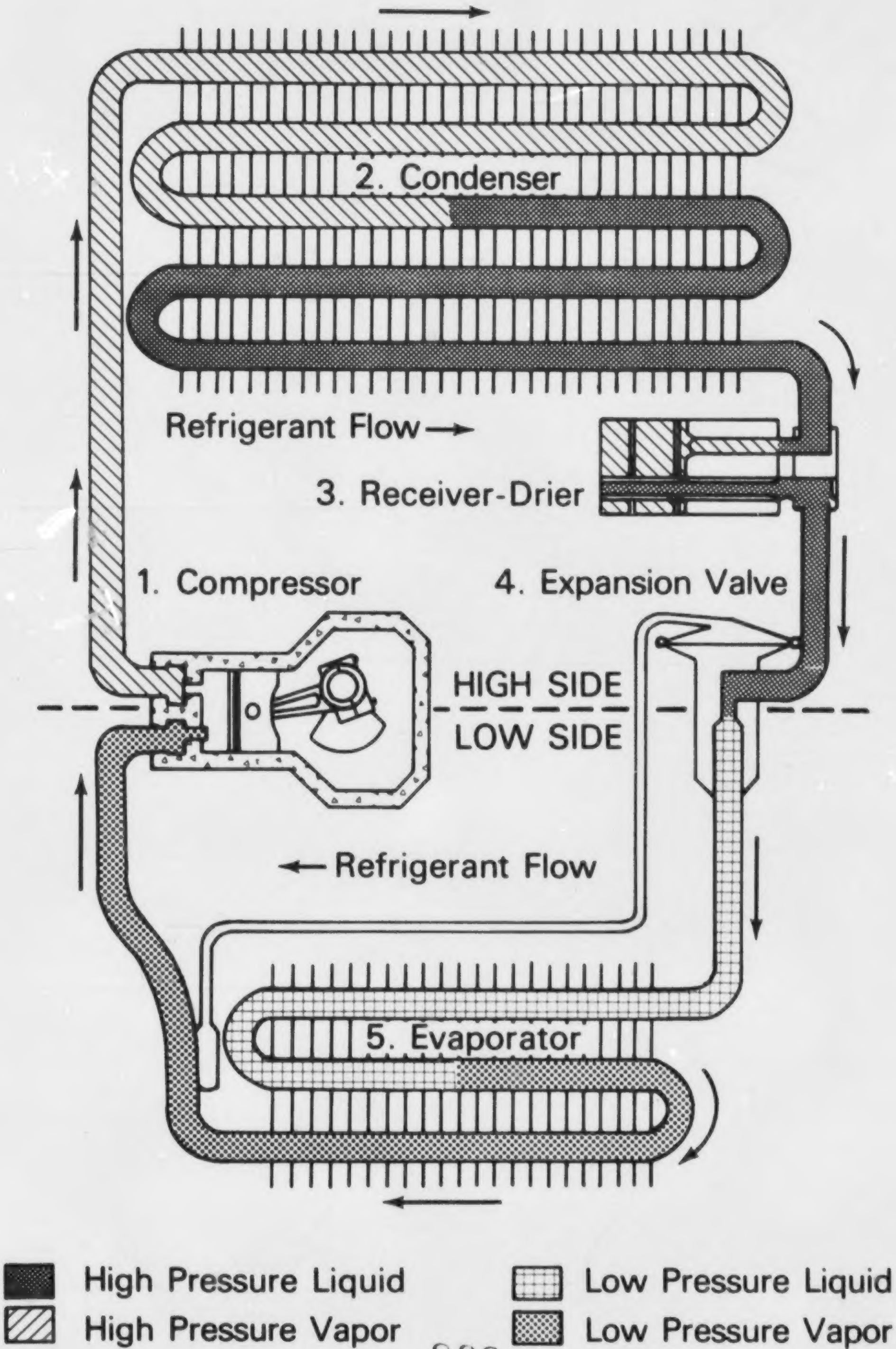
Change of State in an Air Conditioning System


B
Heat of Condensation
A
Heat of Evaporation
Condenser
Evaporator

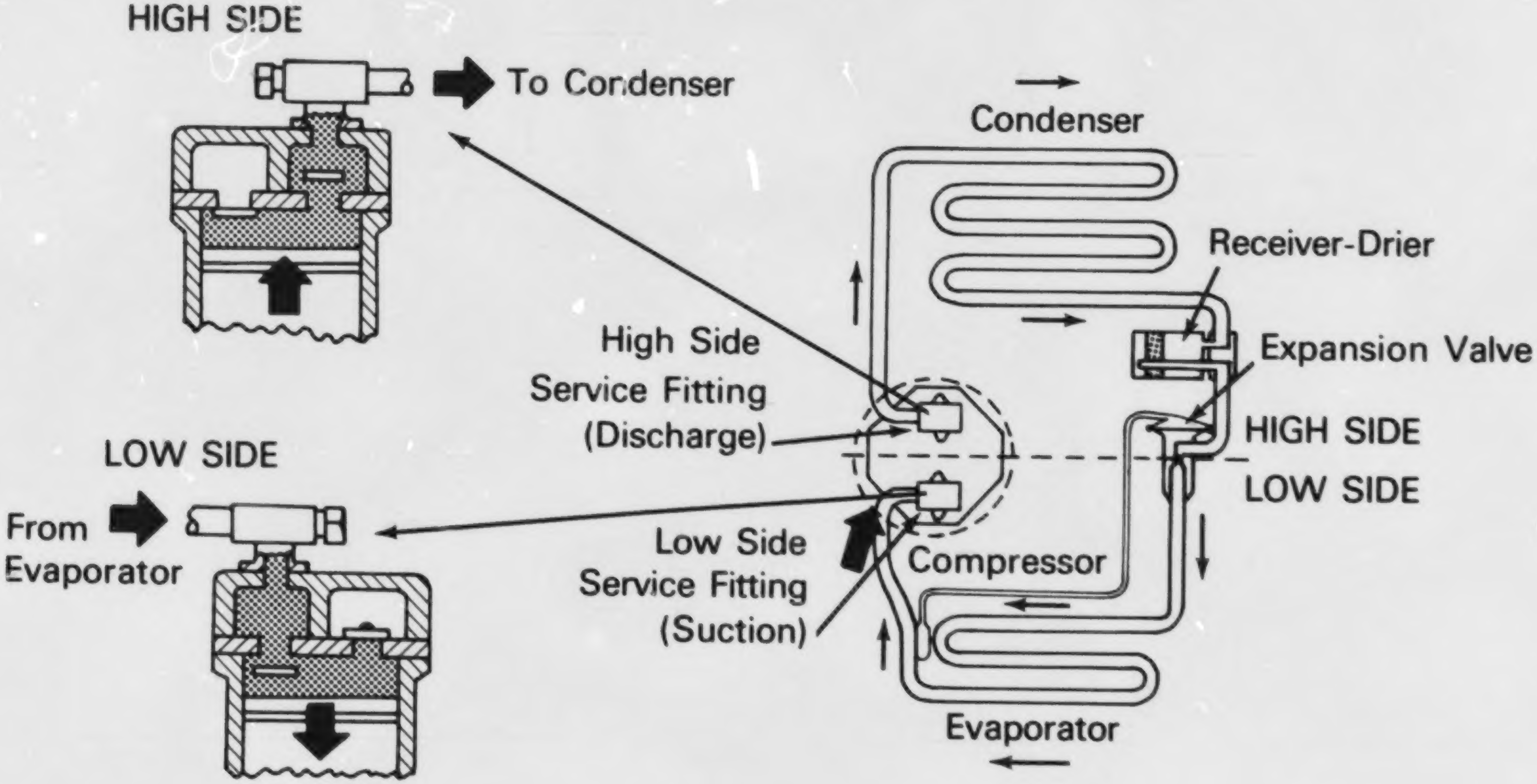
Ⓐ In the Evaporator, R-12 liquid absorbs Heat and becomes a vapor.

Ⓑ In the Condenser, R-12 vapor gives up its Heat and becomes a liquid.

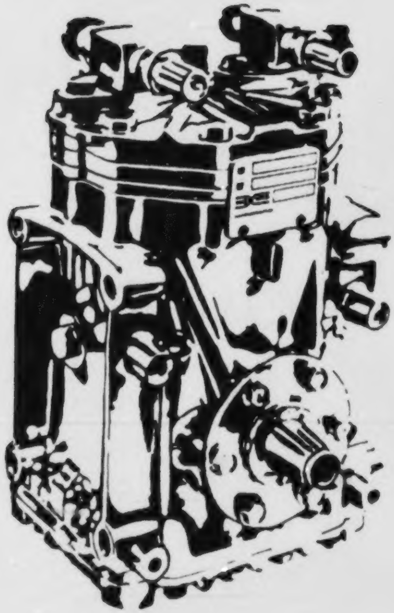
Basic Air Conditioning System Refrigerant Flow Cycle


2. Condenser
Refrigerant Flow →
3. Receiver-Drier
1. Compressor
4. Expansion Valve
HIGH SIDE
LOW SIDE
← Refrigerant Flow
5. Evaporator
High Pressure Liquid
High Pressure Vapor
Low Pressure Liquid
Low Pressure Vapor

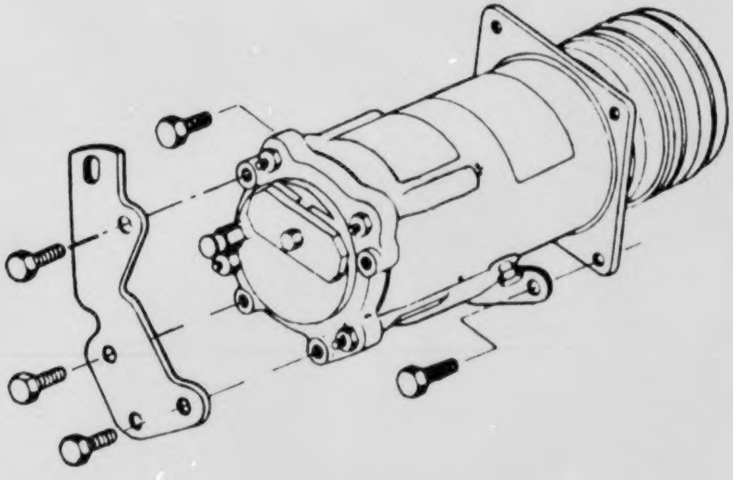
High and Low Sides of a Refrigeration System


HIGH SIDE
To Condenser
LOW SIDE
From Evaporator
High Side Service Fitting (Discharge)
Low Side Service Fitting (Suction)
Condenser
Receiver-Drier
Expansion Valve
HIGH SIDE
LOW SIDE
Compressor
Evaporator

Compressors

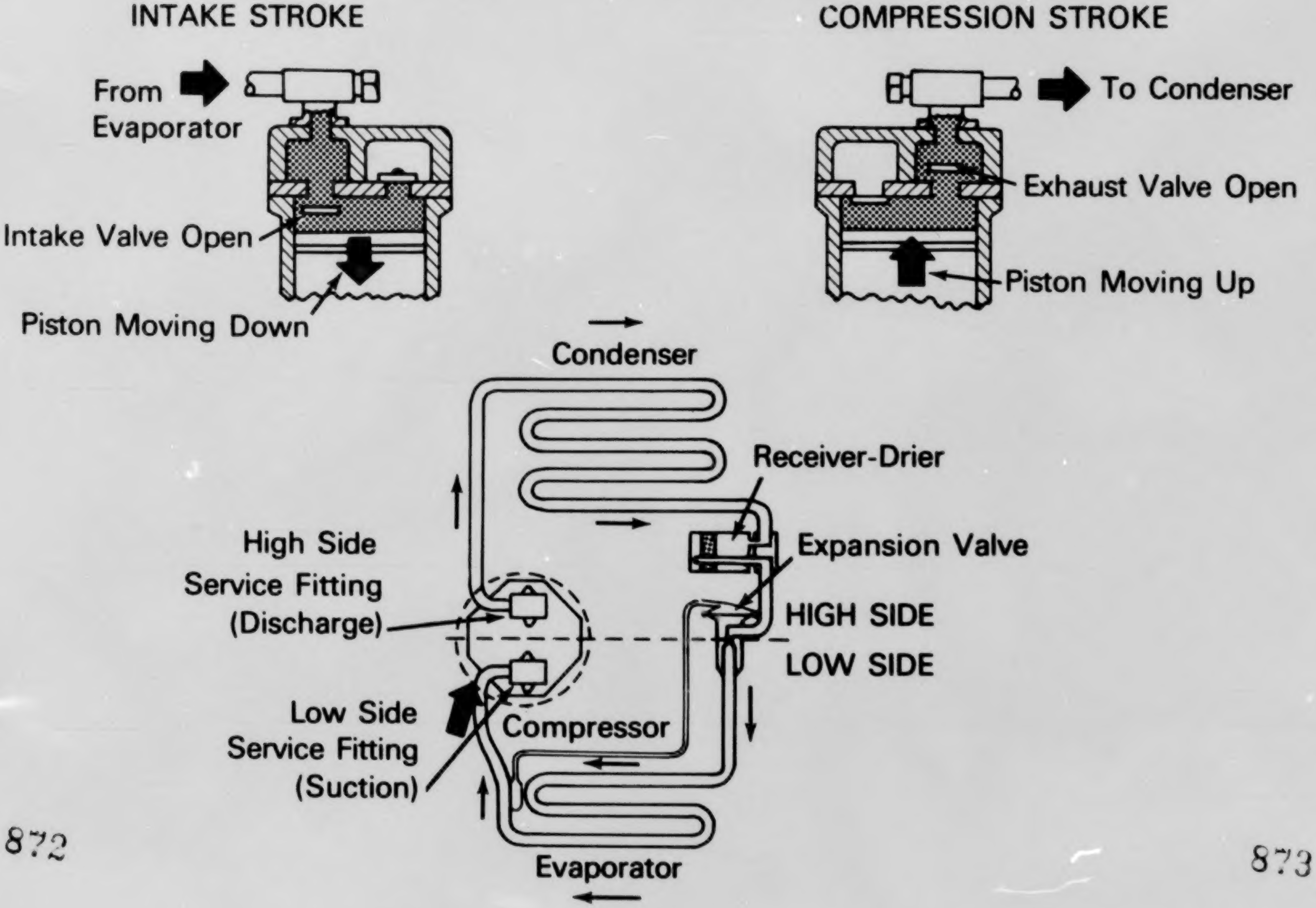


Reciprocating

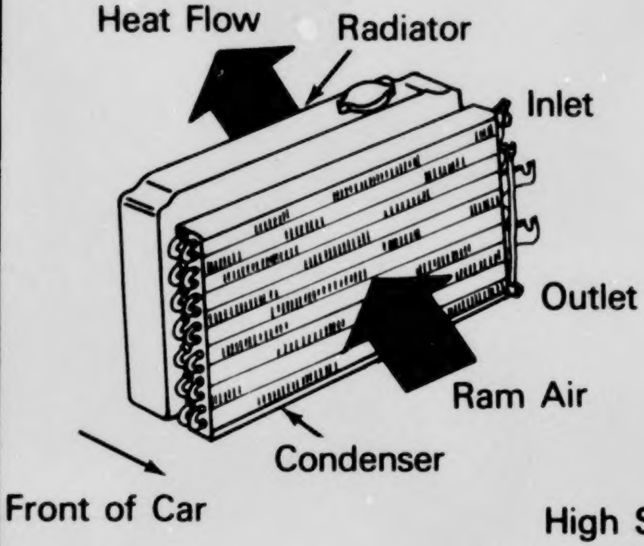


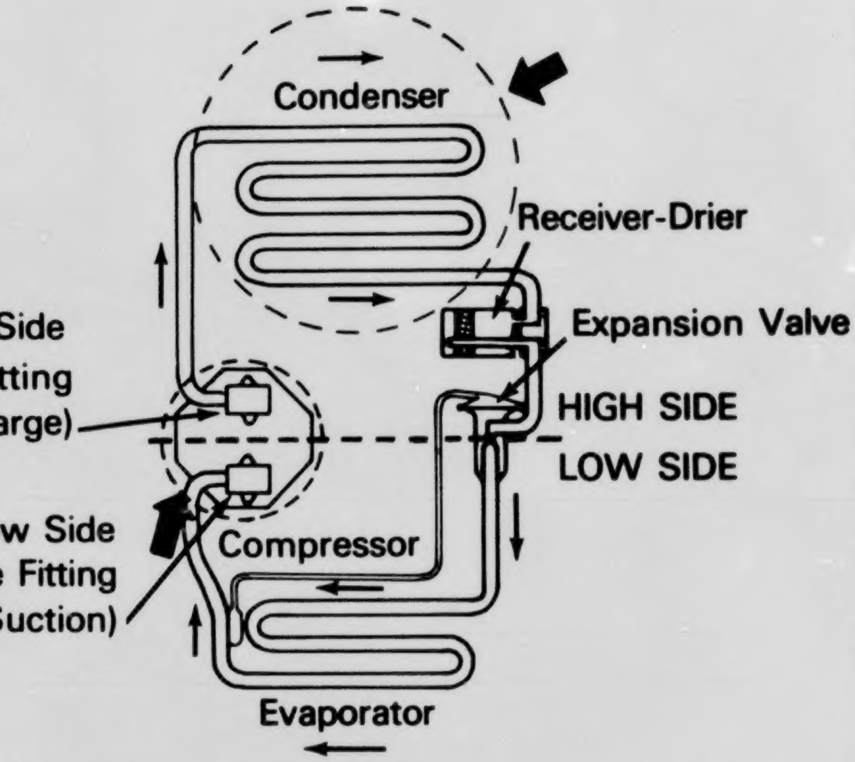
Swash Plate

Compressor Operation


INTAKE STROKE
From Evaporator
Intake Valve Open
Piston Moving Down
COMPRESSION STROKE
To Condenser
Exhaust Valve Open
Piston Moving Up
Condenser
Receiver-Drier
Expansion Valve
HIGH SIDE
LOW SIDE
High Side Service Fitting (Discharge)
Low Side Service Fitting (Suction)
Compressor
Evaporator

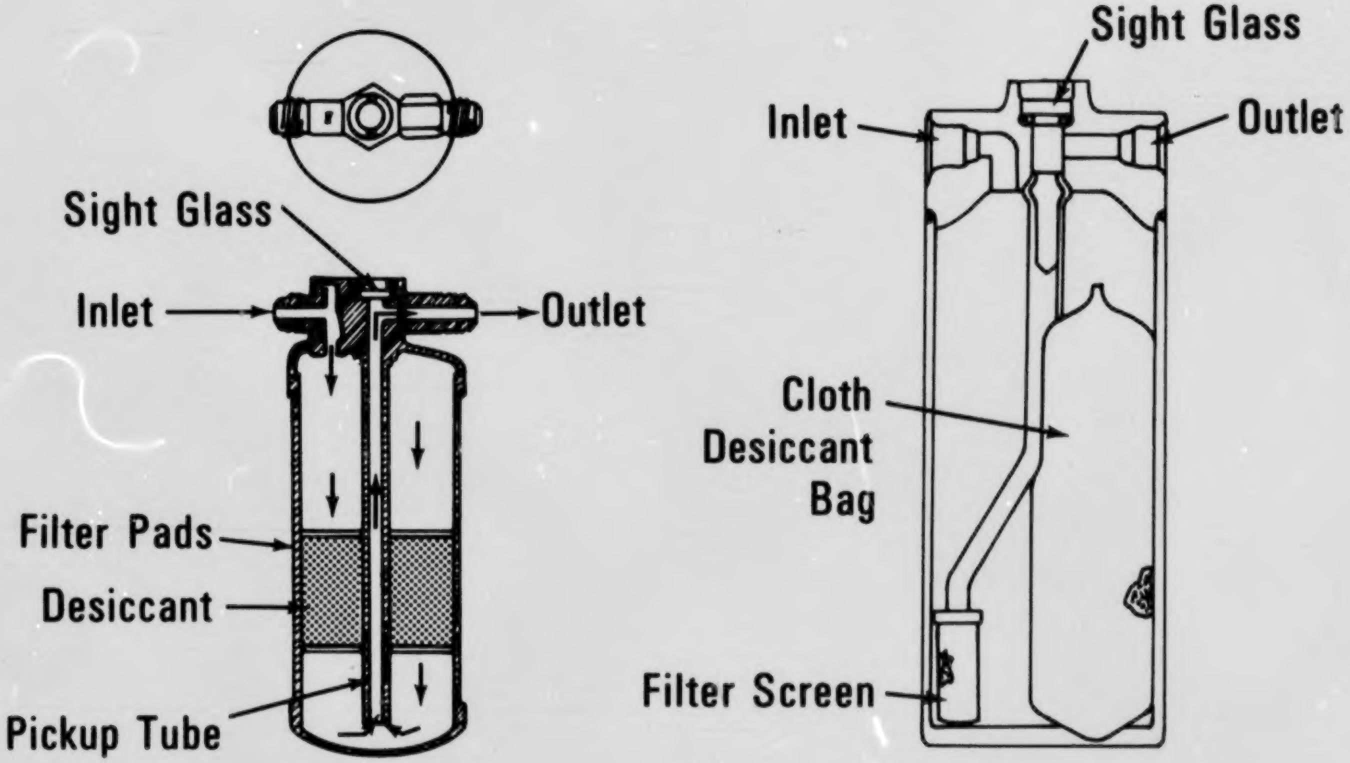
Condenser


Heat Flow
Radiator
Inlet
Outlet
Ram Air
Condenser
Front of Car

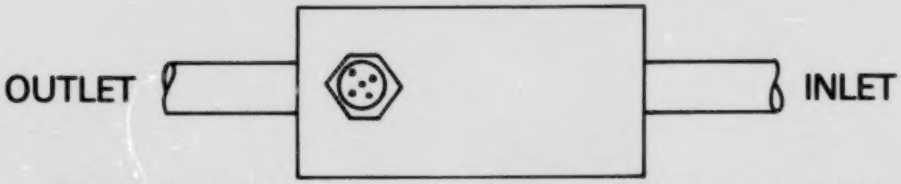

Condenser
Receiver-Drier
Expansion Valve
HIGH SIDE
LOW SIDE
High Side
Service Fitting
(Discharge)
Low Side
Service Fitting
(Suction)
Compressor
Evaporator

Receiver-Drier

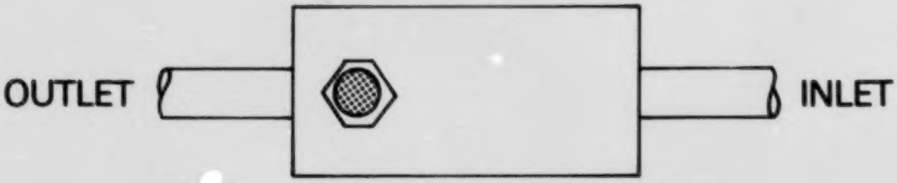
RECEIVER-DRIER ASSEMBLIES
(TYPICAL TYPES)


Sight Glass
Inlet
Outlet
Filter Pads
Desiccant
Pickup Tube
Sight Glass
Inlet
Outlet
Cloth Desiccant Bag
Filter Screen

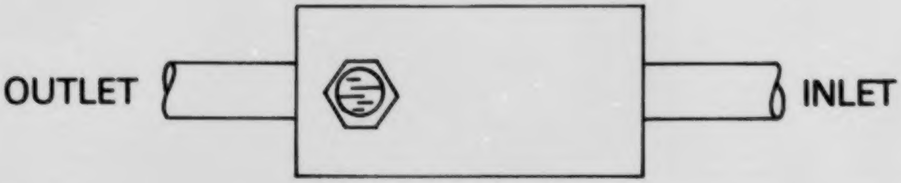
Sight Glass Indications


OUTLET
INLET

Occasional bubbles normal when starting up system
(Refrigerant slightly low or receiver-drier
saturated and releasing moisture)

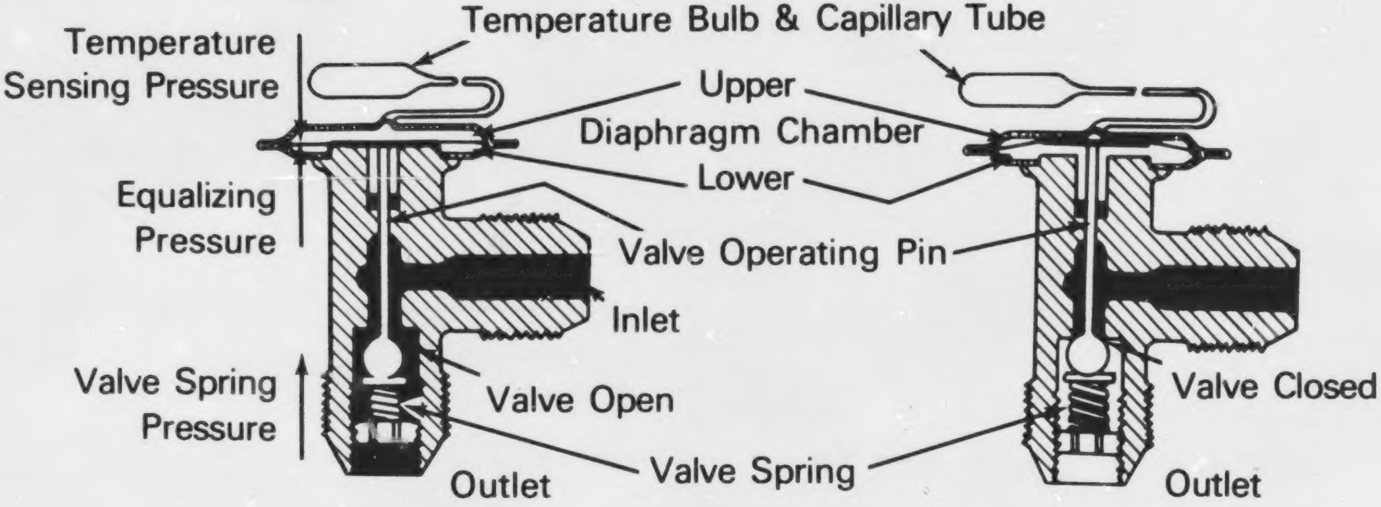

OUTLET
INLET

Foam or heavy stream of bubbles
(Refrigerant very low)


OUTLET
INLET

Oil streaks on glass
(Complete absence of refrigerant)

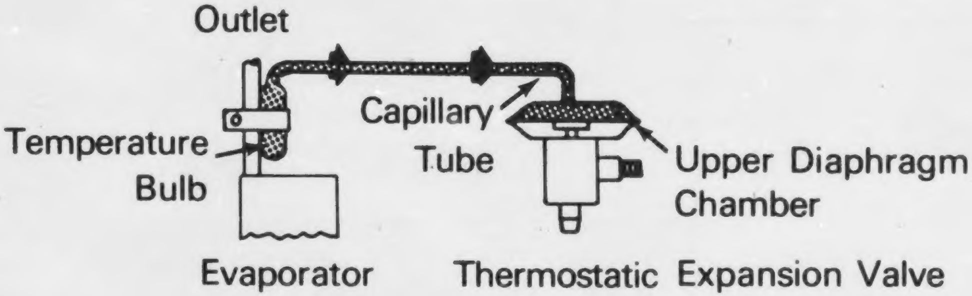
Thermostatic Expansion Valve


Temperature Sensing Pressure
Equalizing Pressure
Valve Spring Pressure
Temperature Bulb & Capillary Tube
Upper
Diaphragm Chamber
Lower
Valve Operating Pin
Inlet
Valve Open
Valve Closed
Valve Spring
Outlet
Outlet

VALVE OPEN

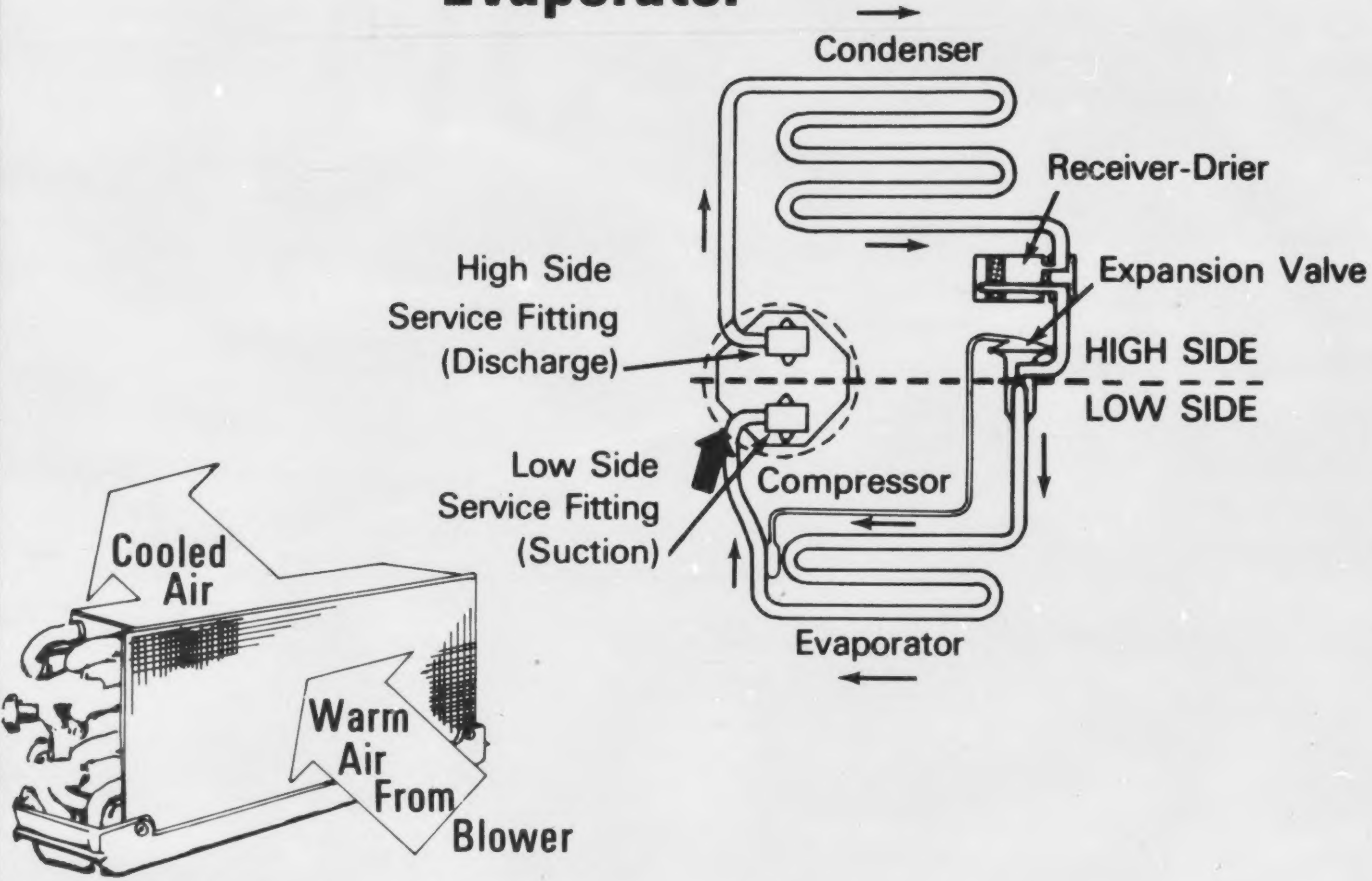
VALVE CLOSED

NOTE: REPLACE VALVE WITH EXACT REPLACEMENT.


Outlet
Capillary Tube
Temperature Bulb
Upper Diaphragm Chamber
Evaporator
Thermostatic Expansion Valve

TEMPERATURE SENSING BULB

Evaporator


Condenser
Receiver-Drier
Expansion Valve
High Side
Service Fitting
(Discharge)
HIGH SIDE
LOW SIDE
Low Side
Service Fitting
(Suction)
Compressor
Evaporator
Cooled
Air
Warm
Air
From
Blower

R-12 Must Be a Vapor at Evaporator Outlet

8

R-12 Refrigerant

Physical Characteristics of Refrigerant-12

Nonflammable

Odorless

Clear in Color

Nontoxic

Noncorrosive to Metal or Rubber Parts

Ideal Operating Pressures

High Stability

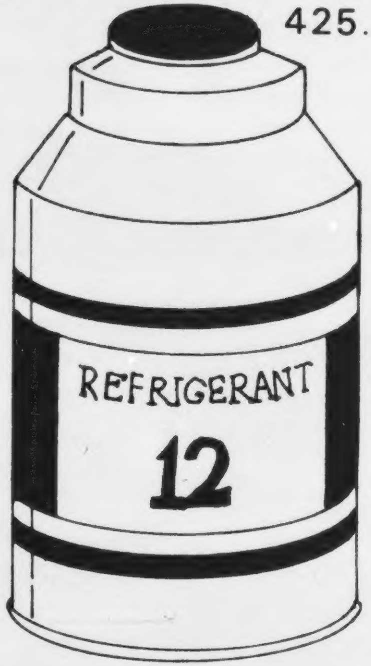
Low Boiling Point

Readily Changes State

Ability to Absorb Great Quantities of Heat

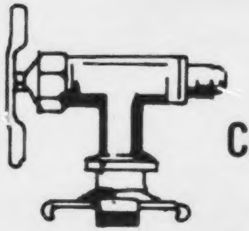
High Affinity for Oil

(The most accepted size is the 15 ounce can.)
425.25 gram

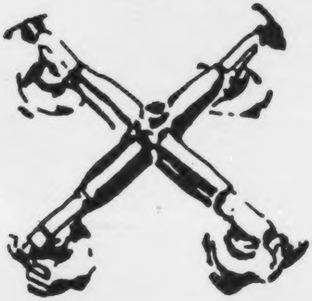


(CAUTION: R-12 only should be used in automotive A.C. systems.)

Refrigerant Can Valve Installation

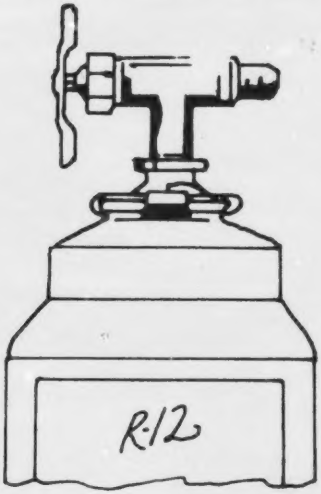


Can Valve



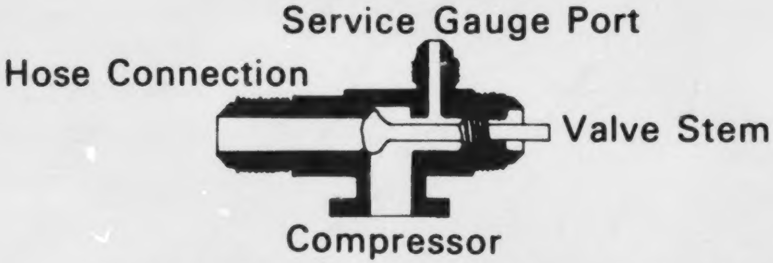
Multiple Dispensing Valve

Can Valve Installed

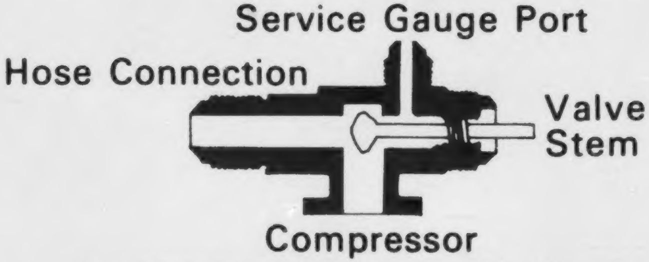


Refrigerant Can

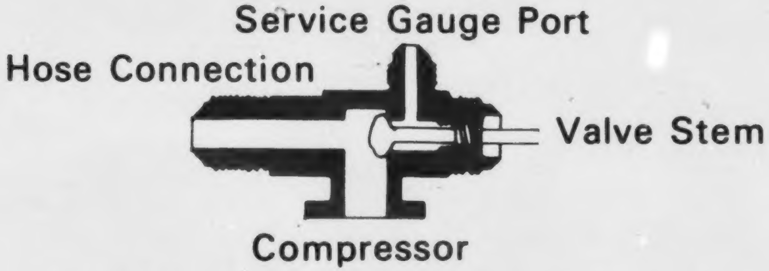
Service Valves


Service Gauge Port
Hose Connection
Valve Stem
Compressor

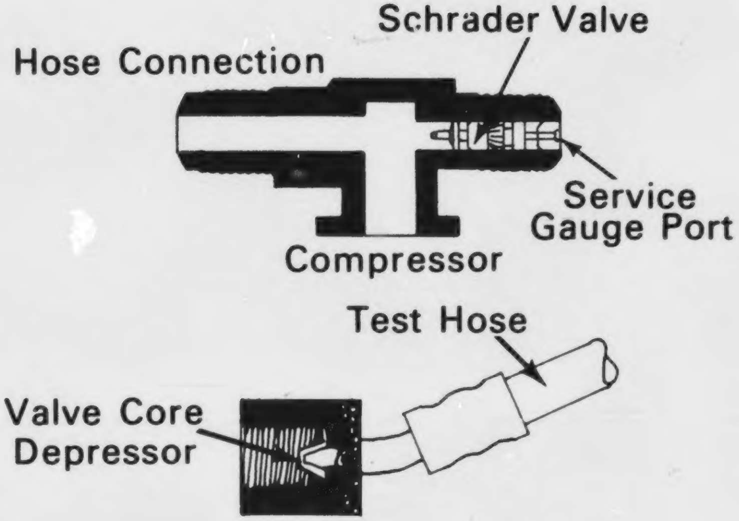
FRONT-SEATED SHUT-OFF POSITION


Service Gauge Port
Hose Connection
Valve Stem
Compressor

MIDPOSITION TEST POSITION

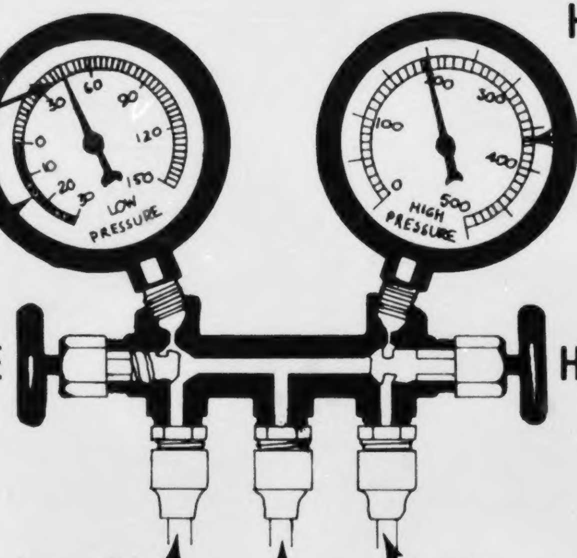

Service Gauge Port
Hose Connection
Valve Stem
Compressor

BACK-SEATED OPERATING POSITION


Schrader Valve
Hose Connection
Service Gauge Port
Compressor
Test Hose
Valve Core Depressor

COMPRESSOR FITTING SCHRADER VALVE

Test Gauge Manifold Set


30
60
90
120
150
0
10
20
30
LOW PRESSURE
0
100
200
300
400
500
HIGH PRESSURE

LOW SIDE GAUGE

Pressure (PSIG)
(Kg/cm^2)

Vacuum (Inches of Vacuum)

HIGH SIDE GAUGE

Pressure (PSIG)
(Kg/cm^2)

LOW SIDE HAND VALVE

HIGH SIDE HAND VALVE

Refrigerant From Low Side

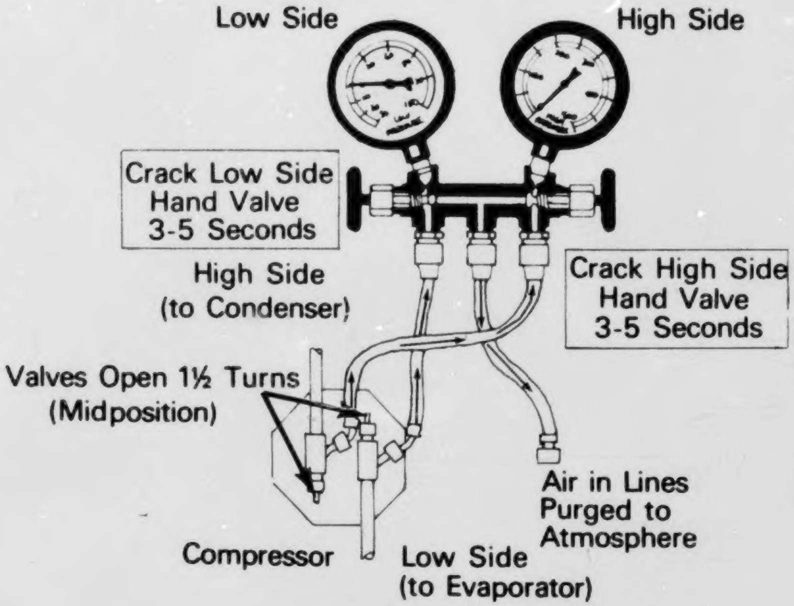
Charging And Purging Hose

Refrigerant From High Side

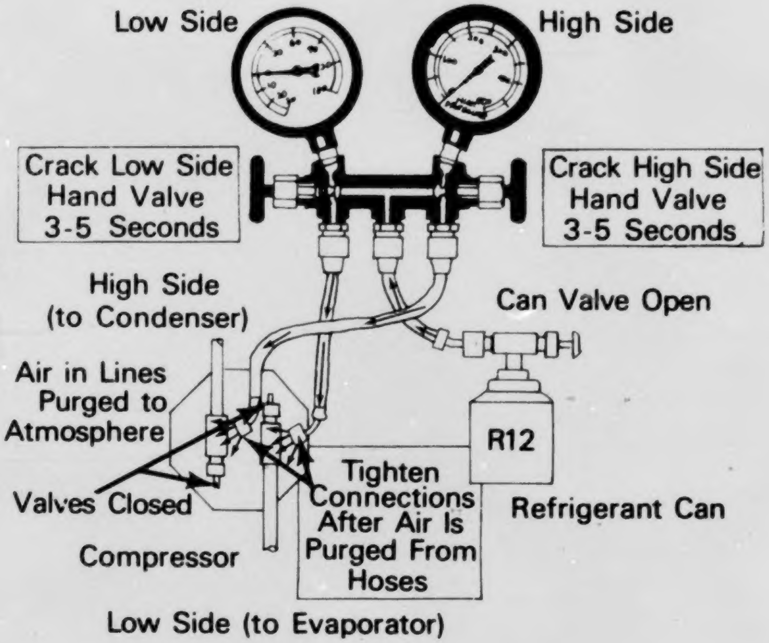
LOW PRESSURE SIDE	HIGH PRESSURE SIDE
Low Side Gauge	High Side Gauge
Manifold	Manifold
Low Side Hand Valve	High Side Hand Valve
Low Side Test Hose	High Side Test Hose

Gauge Test Set Connection to System [Purging]

METHOD 1
(USING SYSTEM REFRIGERANT)


Low Side
High Side
Crack Low Side Hand Valve 3-5 Seconds
High Side (to Condenser)
Crack High Side Hand Valve 3-5 Seconds
Valves Open 1½ Turns (Midposition)
Air in Lines Purged to Atmosphere
Compressor
Low Side (to Evaporator)

METHOD 2
(USING REFRIGERANT CAN)


Low Side
High Side
Crack Low Side Hand Valve 3-5 Seconds
Crack High Side Hand Valve 3-5 Seconds
High Side (to Condenser)
Can Valve Open
Air in Lines Purged to Atmosphere
R12
Tighten Connections After Air Is Purged From Hoses
Valves Closed
Refrigerant Can
Compressor
Low Side (to Evaporator)

NOTE: System must not be operating when purging test hoses.

Pressure-Temperature Relationship

NOTE: Pressures shown are under exact conditions (see Test Conditions) and are not necessarily true for every car checked.
Ambient Temperature is the temperature in the engine compartment (not outside air temperature).

LOW PRESSURE GAUGE READING	EVAPORATOR TEMPERATURE F°
10	2
12	6
14	10
16	14
18	18
20	20
22	22
24	24
26	27
28	29
30	32
35	36
40	42
45	48
50	53
55	58
60	62
65	66
70	70

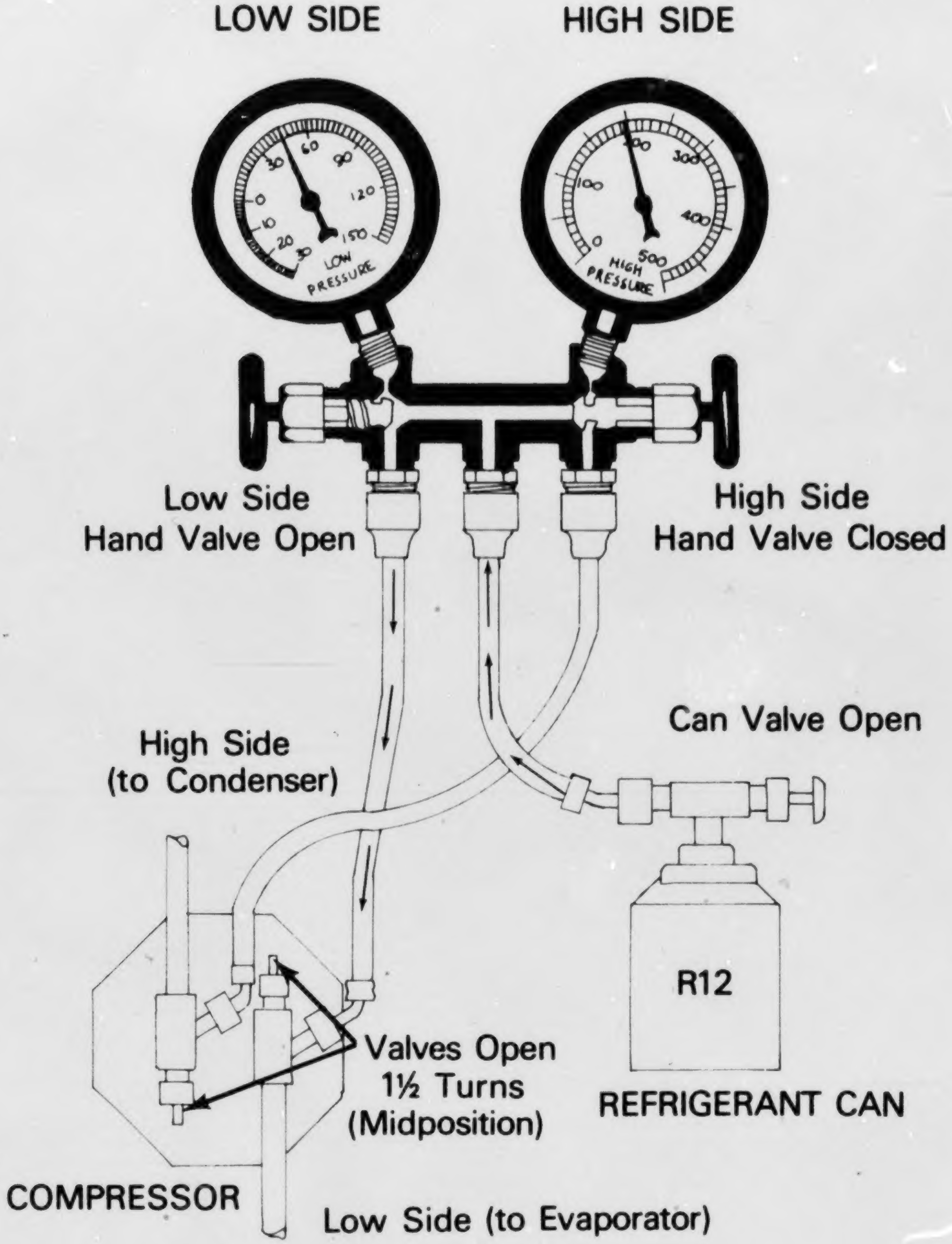
Normal operating ranges shown by dotted line boxes.

AMBIENT TEMPERATURE °F	HIGH PRESSURE GAUGE READING
60	95-115
65	105-125
70	115-135
75	130-150
80	150-170
85	165-185
90	175-195
95	185-205
100	210-230
105	230-250
110	250-270
115	265-285
120	280-310

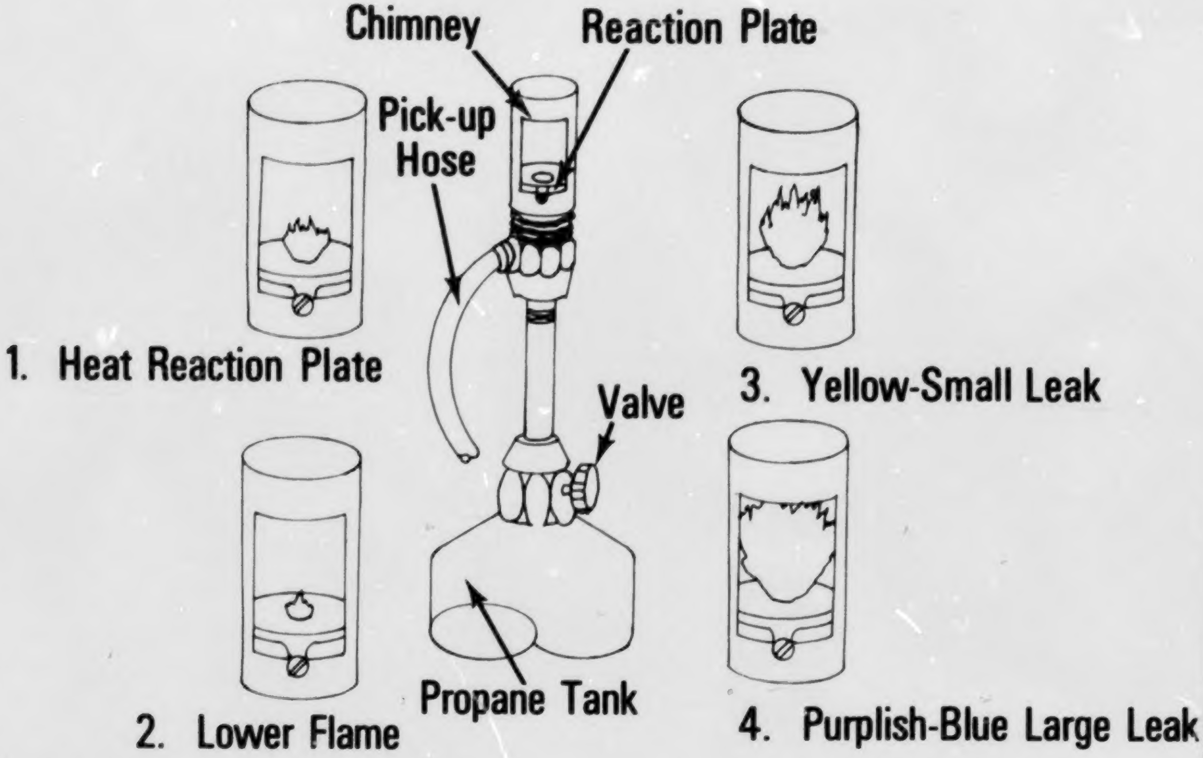
TEST CONDITIONS:

1. Use Large Fan to substitute for normal ram air flow through condenser.
2. Car engine adjusted to normal fast idle speed.
3. System fully charged.
4. All conditions equivalent to 30 MPH.

Adding Refrigerant to System


LOW SIDE
HIGH SIDE
30
60
90
120
150
0
10
20
30
LOW PRESSURE
100
200
300
400
500
0
HIGH PRESSURE
Low Side
Hand Valve Open
High Side
Hand Valve Closed
Can Valve Open
High Side
(to Condenser)
R12
Valves Open
1½ Turns
(Midposition)
REFRIGERANT CAN
COMPRESSOR
Low Side (to Evaporator)

Halide Leak Detector

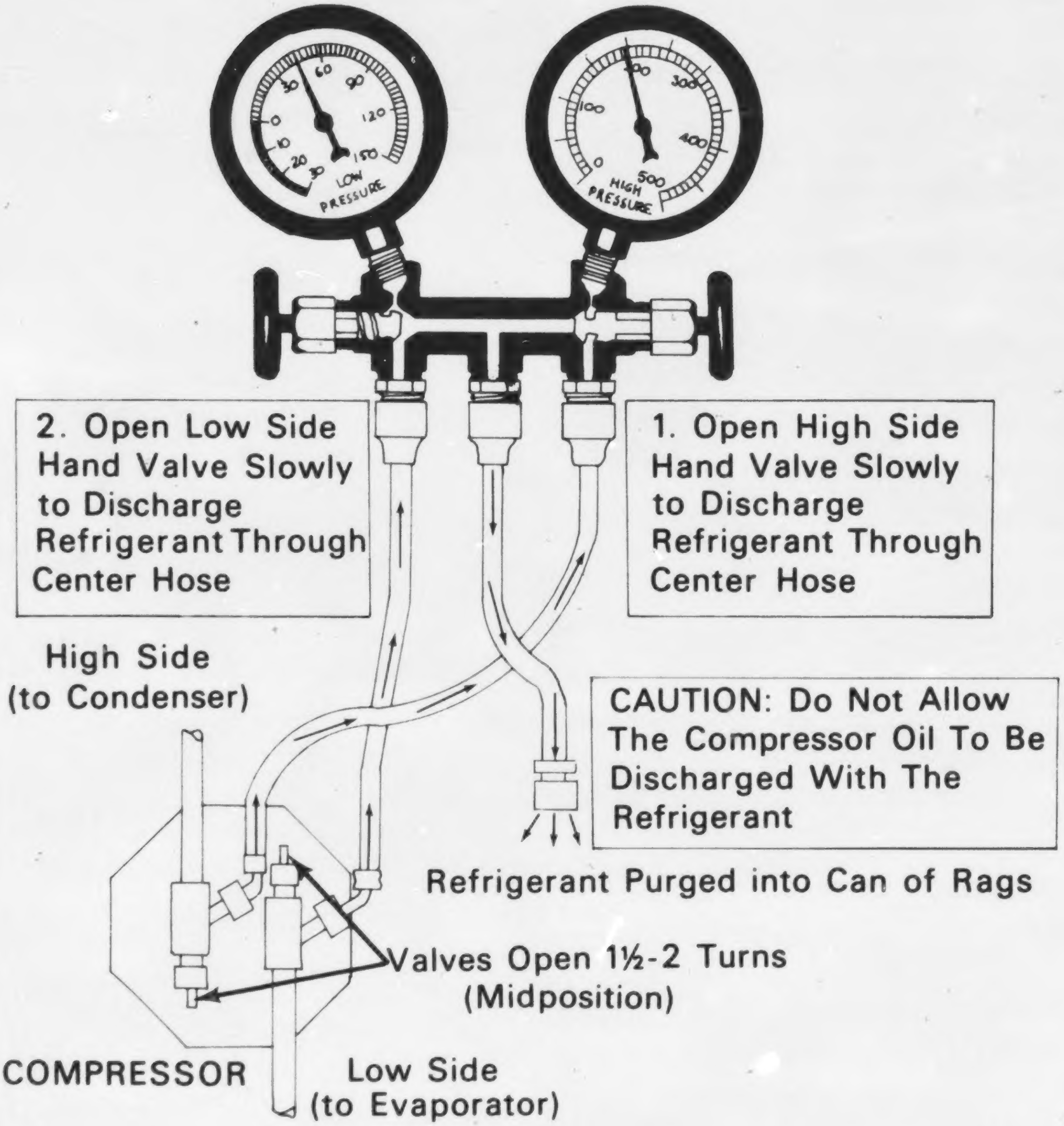

Chimney
Reaction Plate
Pick-up Hose
1. Heat Reaction Plate
3. Yellow-Small Leak
Valve
2. Lower Flame
Propane Tank
4. Purplish-Blue Large Leak

PROPANE TORCH LEAK DETECTOR

Discharging the System

LOW SIDE

HIGH SIDE


30
60
90
120
150
0
10
20
30
LOW PRESSURE
100
200
300
400
500
0
HIGH PRESSURE

2. Open Low Side Hand Valve Slowly to Discharge Refrigerant Through Center Hose

1. Open High Side Hand Valve Slowly to Discharge Refrigerant Through Center Hose

High Side (to Condenser)

CAUTION: Do Not Allow The Compressor Oil To Be Discharged With The Refrigerant

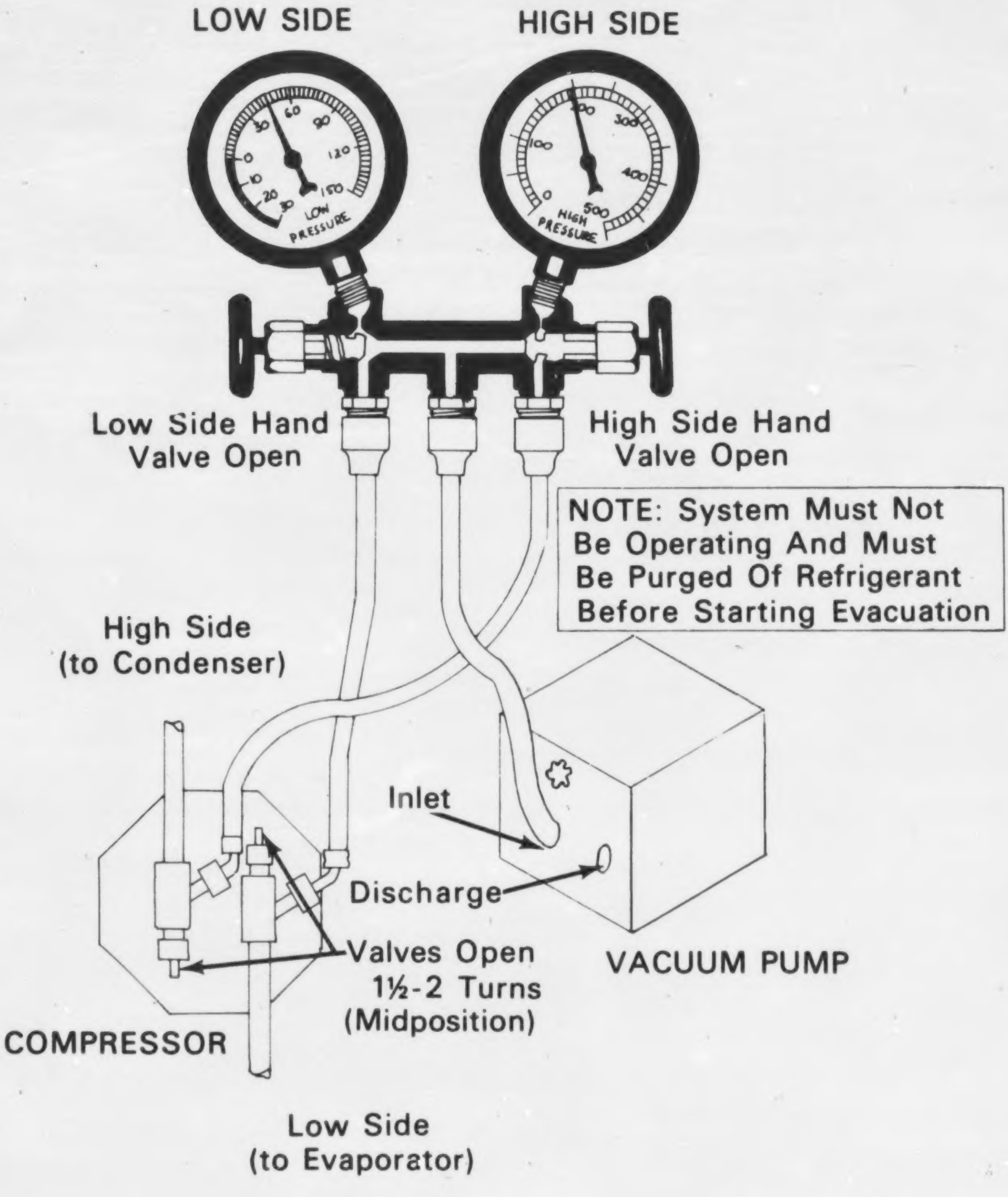
Refrigerant Purged into Can of Rags

Valves Open 1½-2 Turns (Midposition)

COMPRESSOR

Low Side (to Evaporator)

Evacuating the System


LOW SIDE
HIGH SIDE
30
60
90
120
150
0
10
20
30
LOW PRESSURE
100
200
300
400
500
0
HIGH PRESSURE
Low Side Hand Valve Open
High Side Hand Valve Open
High Side (to Condenser)
Inlet
Discharge
Valves Open 1½-2 Turns (Midposition)
VACUUM PUMP
COMPRESSOR
Low Side (to Evaporator)

NOTE: System Must Not Be Operating And Must Be Purged Of Refrigerant Before Starting Evacuation

AIR CONDITIONING
UNIT I

JOB SHEET #1--CONNECT MANIFOLD GAUGE SET INTO SYSTEM

I. Tools and equipment

   A. Manifold gauge

   B. Basic hand tool set

   C. Safety goggles

   D. Service valve ratchet

II. Procedure

   (CAUTION: Wear safety goggles at all times while performing air-conditioning service work.)

   A. Place fender cover on the car fender

   B. Remove caps from service valve stems

   C. Make sure both service valves are in the back seat position, if so equipped

   D. Remove gauge port caps

   E. Connect manifold gauge service hoses to compressor

      1. Connect low manifold hose to low side (suction) of compressor

      2. Connect high manifold hose to high side (discharge) of compressor

         (NOTE: On systems with Schrader type service valves, hoses must be equipped with a depressing pin.)

   F. Set service valves to cracked position

   G. Purge hoses and manifold by momentarily opening each manifold valve

   (NOTE: The manifold gauge set is now ready for use in testing and service work.)

AIR CONDITIONING
UNIT I

JOB SHEET #2--PURGE THE SYSTEM

I. Tools and equipment

- A. Manifold gauge
- B. Basic hand tool set
- C. Service valve ratchet
- D. Safety goggles

II. Procedure

(CAUTION: **Wear safety goggles.**)

A. Turn manifold gauge valves clockwise to full closed position

B. Connect low side manifold to suction side of compressor

C. Connect high side manifold to the discharge side of the compressor

(NOTE: All hose connectors are fingertight only.)

D. Rotate compressor service valve stems two or three turns clockwise on both suction and discharge sides

E. Open manifold valves to allow refrigerant to bleed off through center hose on low side and high side of manifold

(NOTE: The center hose should be placed in a clean rag. If any refrigerant oil is pulled out of the system, it will show up on the rag. Open valves only enough to bleed off refrigerant. Purging rapidly will draw excessive oil from the system. Gauge will read zero when system is purged.)

F. Close manifold valves when refrigerant ceases to bleed

G. Remove parts from system as required

H. Cap or seal all openings and hoses to prevent dirt or foreign matter from entering the system

AIR CONDITIONING
UNIT I

JOB SHEET #3--REPLACE CONDENSER

I. Tools and equipment

- A. Basic hand tool set
- B. Safety goggles
- C. Flare nut wrench set
- D. Service valve ratchet

II. Procedure

(CAUTION: Wear safety goggles.)

A. Remove all body parts as required to get to condenser

B. Purge the air-conditioning system

C. Remove bolts or screws from condenser bracket

D. Disconnect gas inlet line and liquid outlet line from condenser

E. Remove condenser from automobile

(NOTE: Some condensers are equipped with neoprene O-rings which should be replaced before installing condenser. If the condenser is going to be off the automobile for several hours, seal all hose or line openings.)

F. Repair or replace condenser

(NOTE: Have condenser repaired by a professional. Do not attempt it yourself.)

G. Bolt or screw condenser to automobile

(NOTE: Remember that the refrigerant flows out of the bottom of the condenser toward the thermostatic expansion valve.)

H. Connect hoses or lines to condenser

(NOTE: Be sure you have a good seat between condenser and line.)

AIR CONDITIONING
UNIT I

JOB SHEET #4--EVACUATE THE SYSTEM USING A VACUUM PUMP OR CHARGING STATION

I. Tools and equipment

- A. Manifold gauge
- B. Vacuum pump
- C. Basic hand tool set
- D. Safety goggles
- E. Service valve ratchet

II. Procedure

(CAUTION: Wear safety goggles.)

- A. Connect manifold gauge to system with valves closed
- B. Place high and low side compressor service valves in the cracked position
- C. Purge all refrigerant from the system
- D. Remove protective caps from the inlet and exhaust of the vacuum pump

  (NOTE: Make sure the caps are removed to avoid damage to the vacuum pump.)

- E. Connect the center manifold hose to the inlet of the vacuum pump
- F. Start vacuum pump
- G. Open low side of manifold valve and observe gauge needle

  (NOTE: The needle should pull down into a slight vacuum. After five minutes, the compound gauge should read at least 20" vacuum. If not, there is a leak in the system.)

- H. Close manifold low side valve

  (NOTE: Operate vacuum pump for a minimum of fifteen minutes. Low manifold gauge should read 24"-26" vacuum.)

  1. Repair leaks

     (NOTE: If system does not go down to 24"-26" vacuum, close low side and observe gauge. If gauge rises, leak is indicated and must be located and repaired.)

JOB SHEET #4

2. Pump down system

   (NOTE: If no leak is found or if leak is repaired, continue pumping down for a minimum of thirty minutes or longer if time permits.)

I. Shut off vacuum pump

J. Check for vacuum readings and leaks

(NOTE: The compound gauge should read about 29" vacuum and should not rise at a rate faster than 1" in five minutes. If the system fails to meet this requirement, a partial charge must be installed and the system leak must be tested. If leaks are indicated, the system will have to be repaired, purged, and evacuated. If the system holds the vacuum as specified, continue with the charging procedure.)

AIR CONDITIONING
UNIT I

JOB SHEET #5--LEAK TEST THE SYSTEM USING A HALIDE LEAK DETECTOR

I. Tools and equipment

  A. Manifold gauge set

  B. Halide leak detector

  C. Basic hand tool set

  D. Safety goggles

  E. Service valve ratchet

  F. Refrigerant (R-12)

  G. Refrigerant can valve

II. Procedure

  (CAUTION: Wear safety goggles.)

  A. Connect manifold gauge set into system

  B. Place high and low side manifold valves in the closed position

  C. Place high and low side compressor service valves in the cracked position, if so equipped

  D. Check presence of refrigerant in the system

  (NOTE: A minimum of 50 pounds of pressure [344.73 kPa] is needed for leak detection. Higher pressures may be required to find very small leaks.)

  E. Add refrigerant if 50 pounds of pressure (344.73 kPa) is not present

    1. Open high and low side manifold valves to purge hoses and then close valves

    2. Attach center manifold hose to refrigerant container

    3. Open refrigerant container valve

    4. Open low side manifold valve until a pressure of 50 pounds (344.73 kPa) is reached on the high side gauge; then close the low side valve

    5. Close refrigerant container valve

JOB SHEET #5

F. Open valve and light the gas of the halide leak detector

(NOTE: Adjust flame until it burns about 1/2 inch [1.257 cm] above reactor plate. Let it burn until the reactor plate, a copper element, turns to a cherry red color. Lower flame until it is about 1/4" [0.63 cm] above or even with the reactor plate.)

G. Check air-conditioning system for leaks

1. Move the search hose under all joints, connections, seals, and control devices

2. Disconnect any vacuum hoses in the system and check for leaks

(NOTE: For the reaction of the halide leak detector in presence of refrigerant, refer to the chart below. If the system has been purged, the leak detector may sense refrigerant in the atmosphere and indicate a leak when there is none.)

Pale blue	No refrigerant loss
Pale yellow at edges of flame	Very small refrigerant loss
Yellow	Small amount of refrigerant loss
Purplish blue	Large amount of refrigerant loss
Violet	Heavy amount of refrigerant loss; may be great enough to extinguish flame

AIR CONDITIONING
UNIT I

JOB SHEET #6--CHARGE THE AIR-CONDITIONING SYSTEM USING POUND CANS

I. Tools and equipment

  A. Manifold gauge set

  B. Vacuum pump

  C. Refrigerant can valve

  D. Basic hand tool set

  E. Safety goggles

  F. Service valve ratchet

  G. Refrigerant (R-12)

II. Procedure

(CAUTION: Wear safety goggles.)

  A. Charge the air-conditioning system

  (CAUTION: At temperatures above 130°F [54°C], liquid will completely fill a container and pressure will build up rapidly with each container. Never apply a direct flame or an electric resistance heater to a container. Do not abuse a refrigerant container. Use only approved wrenches to open and close valves. Store containers in upright positions. Do not handle refrigerant without suitable eye protection and do not discharge refrigerant into an enclosed area having an open flame.)

  B. Prepare system

    1. Connect manifold gauge set into the system with both manifold valves in the front seat position

    2. Set compressor high and low side service valves in the cracked position

    3. Install can valve to can of refrigerant

      a. Set can valve in the counterclockwise position

      b. Attach valve to refrigerant container and secure locking nut if so equipped

      c. Connect center manifold hose to can valve

      d. Pierce can by turning shut-off valve in the clockwise position

JOB SHEET #6

C. Purge line of air

1. Turn can valve counterclockwise

   (NOTE: Center hose is now charged with refrigerant and air. Do not crack high or low side manifold valves.)

2. Loosen center hose connector at manifold set until a hiss can be heard

   (NOTE: Allow gas to escape for a few seconds and then tighten fingertight.)

D. Charge system

1. Close both manifold valves

2. Start engine and adjust speed to about 1250 rpm

   (NOTE: Speed adjustment may be accomplished by turning idle screw or setting on choke fast-idle cam.)

3. Adjust controls

4. Open low side manifold valve and allow refrigerant, in the gas state, to enter the system

5. Control suction pressure to a maximum of 50 pounds (344.73 kPa)

   (NOTE: After pressure on low side has dropped below 40 pounds [275.79 kPa], the can may be inverted for more rapid removal of refrigerant. To determine when can is empty, tap it on the bottom. A hollow ring should be heard when empty.)

   (CAUTION: With the refrigerant can inverted, vapor will rise to the top of the container and liquid refrigerant will be forced into the charging hoses. DO NOT invert the refrigerant containers with low side pressures in excess of 40 pounds [275.79 kPa]. Regulating the valve on the container or the manifold valve will insure a pressure of 40 pounds [275.79 kPa] or below. Liquid refrigerant entering the compressor low side can cause serious damage to internal parts such as pistons, valves, head, and head gaskets. Never apply heat to refrigerant containers.)

JOB SHEET #6

5. Repeat with additional cans of refrigerant as required to completely charge the system

   (NOTE: Refer to manufacturer's recommendations for system capacity. If system capacity is not known, charge unit until the sight glass is clear and then add one-fourth pound [1.814 kg]).

E. Complete system charge

   1. Close low side manifold valve
   2. Close refrigerant can valve
   3. Remove can valve from center hose
   4. Decrease engine rpm to normal
   5. Turn system off
   6. Turn engine off
   7. Back seat compressor service valves
   8. Remove manifold gauge set
   9. Replace all protective caps and covers

AIR CONDITIONING
UNIT I

JOB SHEET #7--REMOVE AND REPLACE COMPRESSOR CRANKSHAFT SEAL

I. Tools and equipment

   A. Basic hand tool set

   B. Shop towels

   C. Refrigeration oil

   D. Manifold gauge set

   E. Compressor clutch puller

   F. Safety goggles

   G. Refrigerant 12 (R-12)

   H. Refrigerant leak tester

II. Procedure

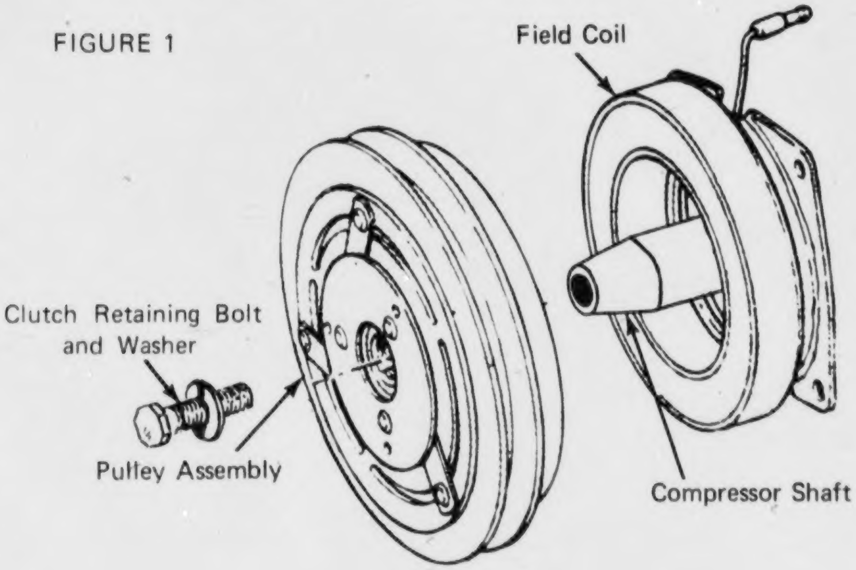
   (NOTE: Procedures outlined in this job sheet are for the York or Tecumseh compressors.)

   A. Discharge system

   B. Remove the clutch pulley assembly (Figure 1)

   C. Remove clutch field assembly (Figure 1)

FIGURE 1


Field Coil
Clutch Retaining Bolt and Washer
Pulley Assembly
Compressor Shaft

JOB SHEET #7

D. Remove woodruff key

(NOTE: Use care to avoid marring compressor shaft.)

E. Remove secondary dust shield, if so equipped

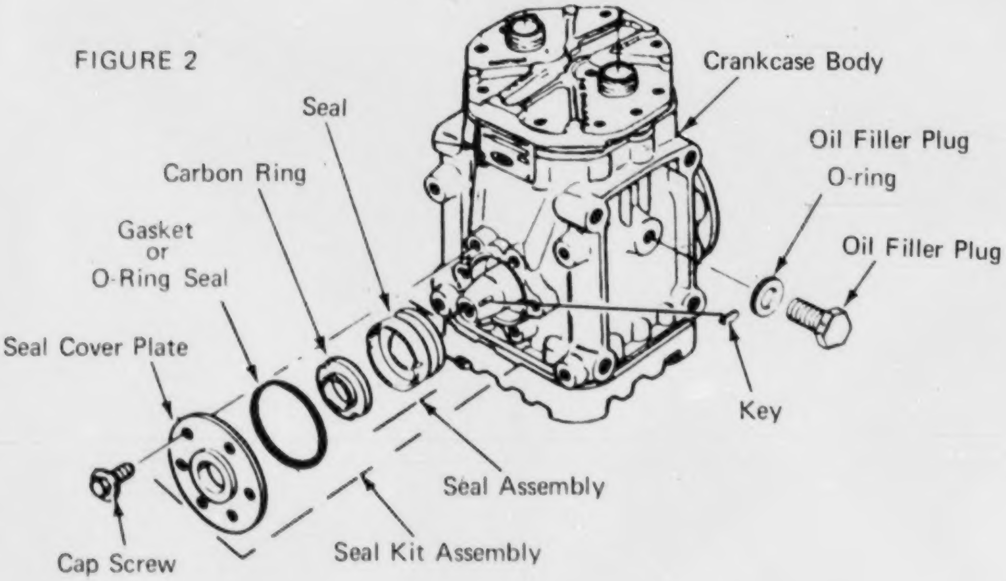
F. Clean all accumulated dirt and foreign material from seal cover plate area

G. Remove cap screws from seal cover plate (Figure 2)

H. Remove seal cover plate (Figure 2)

I. Remove seal carbon ring and seal housing assembly (Figure 2)

FIGURE 2


Crankcase Body
Seal
Oil Filler Plug O-ring
Carbon Ring
Oil Filler Plug
Gasket or O-Ring Seal
Seal Cover Plate
Key
Seal Assembly
Cap Screw
Seal Kit Assembly

J. Remove O-ring seal or clean old gasket from compressor as required

K. Check compressor shaft for nick or burrs and repair as necessary

L. Inspect compressor internal parts for damage

M. Check compressor oil level

1. Remove plug on side of compressor crankcase (Figure 3)

2. Fabricate as gauge stick from a piece of wire

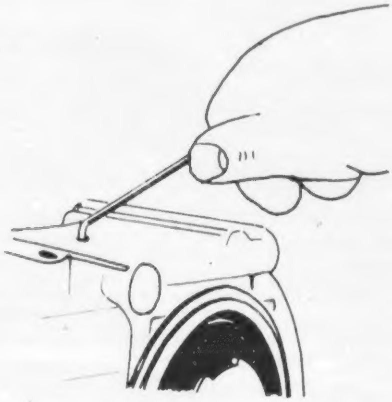
   (NOTE: The wire should be bent so as to reach the bottom of the compressor crankcase.)

JOB SHEET #7

3. Check oil level with the gauge

   (NOTE: The oil level should be approximately one inch [25.4 mm] deep.)

FIGURE 3



4. Add oil as necessary

   (CAUTION: Excessive amounts of oil in the air-conditioning system will cause poor operation of the system.)

5. Replace crankcase plug

N. Wash the new seal assembly components in clean refrigeration oil

O. Place the seal housing assembly over the end of the shaft with the end that fits the carbon facing outward

(NOTE: The seal housing should be seated against the stop or bearing race.)

P. Position the carbon ring over the shaft and to the seal housing so that the raised rim and polished surface of the ring faces outward

Q. Install cover plate gasket or O-ring on compressor

(NOTE: Both the seal and O-ring should be coated with clean refrigeration oil before installation.)

R. Position the seal cover plate assembly over the compressor shaft so that the polished surface of the plate and seal carbon ring contact squarely

S. Align cover plate and install cap screws

JOB SHEET #7

T. Torque the cap screws in a circular sequence to 75 inch pounds [8.472 N·m]

U. Rotate the compressor shaft approximately ten times to seat the seal

V. Install woodruff key

W. Install clutch field coil

X. Install clutch pulley assembly while aligning the keyway with the woodruff key

Y. Install and torque clutch retaining bolt

Z. Evacuate the system

AA. Charge the system with refrigerant 12

BB. Leak test the new seal

AIR CONDITIONING
UNIT I

TEST

NAME ______________________________ SCORE ______________

1. Match the terms on the right to the correct definitions. (Answers for "a" through "j" are on this page.)

_____a. Device used to control temperature, humidity, and air movement

_____b. Adjustable door in the plenum blower assembly that permits selection of outside and inside air for heating and cooling systems

_____c. Temperature of air surrounding an air-conditioned unit, such as a vehicle or building

_____d. Outside air sensing switch used to control compressor clutch operation and prevent compressor operation at low temperatures when air conditioning is not required

_____e. Act of turning the service valve stem all the way counterclockwise until the valve is seated

_____f. Motor-driven fan used to force air through the evaporator and to circulate the cooled air through the passenger compartment of the automobile

_____g. Temperature at which a liquid changes to a vapor

_____h. Mechanical device used to pierce, dispense, and seal small cans of refrigerant

_____i. Specific amount of refrigerant or oil by volume or weight

_____j. Act of placing a charge of refrigerant or oil into the air conditioning system

1. Back seating
2. Can valve
3. Ambient compressor switch
4. Air inlet valve
5. Charging
6. Blower fan
7. Air-conditioner
8. Charge
9. Boiling point
10. Ambient air temperature

(Answers to "k" through "v" are on this page.)

_____k. Gas; gaseous state of refrigerant

_____l. Gauge that will register both pressure and vacuum; used on the low side of the system

_____m. Component of the refrigeration system that pumps refrigerant vapor and increases the pressure of the refrigerant

_____n. Assembly mounted on the compressor crankshaft permitting the shaft to be turned without loss of refrigerant or oil

_____o. Act of changing a vapor to a liquid

_____p. Component of a refrigeration system in which refrigerant vapor is changed to a liquid by the removal of heat

_____q. Substance other than refrigerant and refrigeration oil in the system

_____r. Drying agent used in refrigeration systems to remove excess moisture

_____s. To bleed some or all of the refrigerant from a system by opening a valve or connection and permitting the refrigerant to escape slowly

_____t. Hose that connects the compressor outlet to the condenser inlet

_____u. That portion of the refrigeration system under high pressure, extending from the compressor outlet to the thermostatic expansion valve inlet

_____v. Device containing desiccant placed in the liquid line to absorb moisture in the system

11. Compound gauge
12. Vapor
13. Compressor
14. Desiccant
15. Discharge side
16. Condenser
17. Contaminant
18. Discharge
19. Discharge line
20. Condensation
21. Compressor shaft seal
22. Drier

(Answers to "w" through "gg" are on this page.)

_____w. System short of refrigerant which will result in improper cooling

_____x. To create a vacuum within a system to remove all traces of air and moisture

_____y. Component of an air conditioning system in which refrigerant liquid is changed into a vapor by removing heat from the air which is then discharged into the passenger compartment

_____z. Thermometer scale using 0° as the freezing point of water and 100° as the boiling point of water

_____aa. Device used with the drier or as a separate unit to remove foreign solid material from the refrigerant

_____bb. Condition caused by too much liquid refrigerant being metered into the evaporator

_____cc. To remove solid particles such as metal flakes or dirt from refrigerant passages

_____dd. Formation of a froth of the oil and refrigerant due to rapid boiling out of the refrigerant dissolved in the oil when the pressure is suddenly reduced

_____ee. Failure of a unit to operate properly due to the formation of ice at the expansion valve orifice or on the evaporator coils or fins

_____ff. Act of closing compressor service valves by turning them all the way clockwise

_____gg. Pressure of the refrigerant from the discharge reed valve through lines and condenser to the expansion valve orifice

23. Undercharge
24. Celsius
25. Evacuate
26. Flush
27. Evaporator
28. Filter
29. Flooding
30. Foaming
31. Head pressure
32. Freeze-up
33. Front seating

(Answers to "hh" through "tt" are on this page.)

_____hh. Mechanical device used to evacuate the refrigeration system to rid it of excess moisture and air

_____ii. Less than atmospheric pressure; expressed in inches of mercury

_____jj. Device located on the discharge side of the compressor to allow the technician to check high side pressure and perform other necessary operations

_____kk. Low side pressure higher than normal due to a malfunction of the system

_____ll. To isolate or seal off with a nonconductor

_____mm. Any device used to detect leaks in an air-conditioning system

_____nn. Line connecting the drier outlet with the expansion valve inlet

_____oo. High side pressure lower than normal due to a malfunction of the system

_____pp. Device located on the suction side of the compressor to allow the technician to check low side pressure or perform other necessary service operations

_____qq. Pressure lower than normal in the suction side of the system due to a malfunction of the unit

_____rr. Coupling device used to turn the compressor on and off electrically

_____ss. Indication of too much refrigerant or refrigeration oil in the system

_____tt. Force per unit of area; pressure of refrigerant is measured in pounds per square inch (psi) or kilopascals (kPa)

34. Vacuum pump
35. Insulate
36. Liquid line
37. High suction pressure
38. Low head pressure
39. Vacuum
40. Leak detector
41. High side service valve
42. Low side service valve
43. Overcharge
44. Pressure
45. Magnetic clutch
46. Low suction pressure

(Answers to "uu" through "ddd" are on this page.)

______uu. Difference in pressure between any two points that may be caused by a restriction or friction

______vv. To remove moisture and air from a system or a component by flushing with a dry gas refrigerant

______ww. Air that is forced through the condenser coils by the movement of the vehicle or action of the fan

______xx. Combination container for the storage of liquid refrigerant and desiccant

______yy. Positive displacement compressor with pistons that travel back and forth in a cylinder

______zz. Thin leaves of steel located in the valve plate of automotive compressors to act as suction and discharge valves

______aaa. Refrigerant used in automotive air conditioners

______bbb. Complete circulation of refrigerant through an air-conditioning system accompanied by changes in temperature and pressure, such as changes of state from vapor to liquid to vapor

______ccc. Highly refined oil free from all contaminants, such as sulfur, moisture, and tars

______ddd. Sensing device connected to the expansion valve by a capillary tube to sense temperature and transmit pressure to the expansion valve for its proper operation

47. Pressure drop
48. Reciprocating compressor
49. Purge
50. Ram air
51. Receiver-Drier
52. Refrigeration oil
53. Reed valves
54. Refrigeration cycle
55. Refrigerant-12 (R-12)
56. Remote bulb

(Answers to "eee" through "mmm" are on this page.)

_____eee. Spring-loaded valve similar to a tire valve located inside the service valve fitting and used on some control devices to hold refrigerant in the system

_____fff. Housing on the fire wall inside the engine compartment containing air ducts, air valves, and blower

_____ggg. Fitting located on the service valves and on some control devices to connect manifold gauge set charging hoses to air-conditioning system

_____hhh. Condition caused by poor air circulation or a thermostat out of adjustment causing the air-conditioning unit to run for very short periods

_____iii. Line connecting the evaporator outlet to the compressor inlet

_____jjj. That portion of the refrigeration system under low pressure extending from the expansion valve outlet to the compressor inlet

_____kkk. Back pressure regulated device that prevents evaporator core freeze-up

_____lll. Compressor inlet pressure which reflects the pressure of the system on the low side

_____mmm. Temperature-sensitive switch used to control the compressor clutch and cycle the compressor as a means of temperature control in an air-conditioning system

57. Schrader valve
58. Plenum blower assembly
59. Service port
60. Thermostatic switch
61. Suction throttling valve (STV, POA, and EPA valves)
62. Short cycling
63. Suction side
64. Suction pressure
65. Suction line

2. Identify the components of the refrigeration system illustrated below by writing the correct names in the blanks provided.

   a. ______________________________

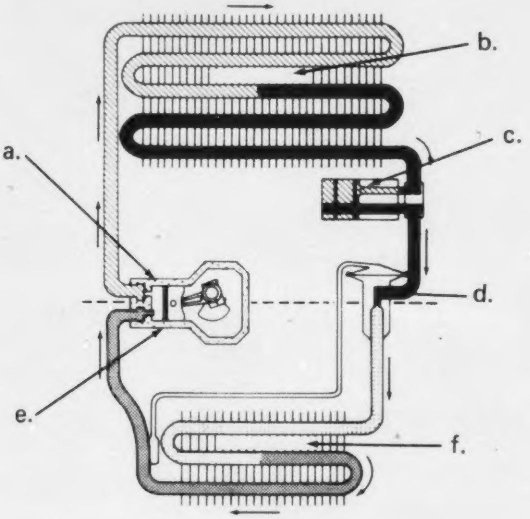
   b. ______________________________

   c. ______________________________

   d. ______________________________

   e. ______________________________

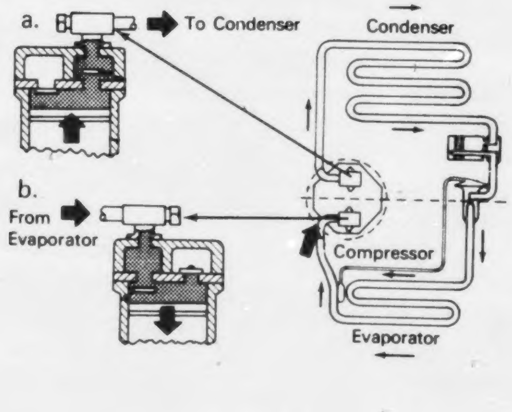
   f. ______________________________



3. Identify the high and low sides of the compressor illustrated below by writing the correct names in the blanks provided.

   a. ______________________________

   b. ______________________________


a.
To Condenser
Condenser
b.
From Evaporator
Compressor
Evaporator

4. List six safety rules for auto air conditioning.

a. ____

b. ____

c. ____

d. ____

e. ____

f. ____

5. Discuss the function of a receiver-drier (dehydrator).

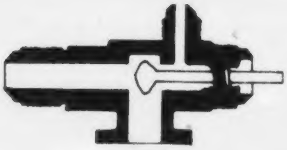
____

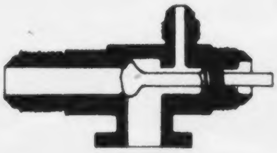
____

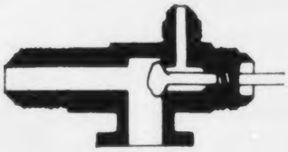
____

____

6. Identify the back seat, midposition, and front seat of a service valve by writing the correct names in the blanks provided.



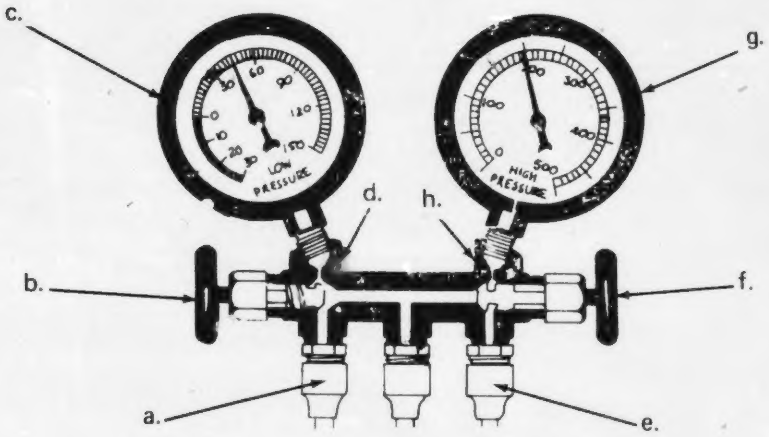




a. ________________ b. ________________ c. ________________

7. Identify the components of the manifold gauge set illustrated below by writing the correct names in the blanks provided.

LOW PRESSURE SIDE	HIGH PRESSURE SIDE
a. ____________________	e. ____________________
b. ____________________	f. ____________________
c. ____________________	g. ____________________
d. ____________________	h. ____________________



8. Demonstrate the ability to:

   a. Connect manifold gauge set into system.

   b. Purge the system.

   c. Replace condenser.

   d. Evacuate the system using a vacuum pump or charging station.

   e. Leak test the system using a halide leak detector.

   f. Charge the air-conditioning system using pound cans.

   g. Remove and replace compressor crankshaft seal.

(NOTE: If these have not been accomplished prior to the test, ask the instructor when the above activities should be completed.)

AIR CONDITIONING
UNIT I

ANSWERS TO TEST

1.	a.	7	aa.	28	aaa.	55
	b.	4	bb.	29	bbb.	54
	c.	10	cc.	26	ccc.	52
	d.	3	dd.	30	ddd.	56
	e.	1	ee.	32	eee.	57
	f.	6	ff.	33	fff.	58
	g.	9	gg.	31	ggg.	59
	h.	2	hh.	34	hhh.	62
	i.	8	ii.	39	iii.	65
	j.	5	jj.	41	jjj.	63
	k.	12	kk.	37	kkk.	61
	l.	11	ll.	35	lll.	64
	m.	13	mm.	40	mmm.	60
	n.	21	nn.	36		
	o.	20	oo.	38		
	p.	16	pp.	42		
	q.	17	qq.	46		
	r.	14	rr.	45		
	s.	18	ss.	43		
	t.	19	tt.	44		
	u.	15	uu.	47		
	v.	22	vv.	49		
	w.	23	ww.	50		
	x.	25	xx.	51		
	y.	27	yy.	48		
	z.	24	zz.	53		

2. a. Discharge side of compressor
   b. Condenser
   c. Receiver-Drier
   d. Expansion valve
   e. Suction side of compressor
   f. Evaporator
3. a. High side
   b. Low side
4. Any six of the following:
   a. Do not inhale fumes from burned fluorocarbon gases
   b. Do not warm a refrigerant can over 125°F (51°C)
   c. Do not abuse a refrigerant container
   d. Do not allow high side pressure to enter refrigerant container
   e. Wear safety glasses and a full face shield or sealed goggles while working on an air-conditioning system
   f. Do not apply torch to a pressurized system
   g. Inspect all pressure hoses, gauges, and connections before using
   h. Ventilate a gas-filled area before working there
   i. Do not pump liquid refrigerant into a compressor
5. To provide storage of liquid refrigerant and to absorb moisture in the system
6. a. Midposition
   b. Front seat
   c. Back seat
7. a. Low side test hose
   b. Low side hand valve
   c. Low side gauge
   d. Manifold

  e. High side test hose

  f. High side hand valve

  g. High side gauge

  h. Manifold

8. Performance skills evaluated to the satisfaction of the instructor

HEATERS
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify the components of the heater. The student should be able to pressure test and back flush the heater core and change flow control valve. The student should be able to test the blower motor. This knowledge will be evidenced through demonstration and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with heaters to the correct definitions.
2. Identify the major components of a heater system.
3. List reasons for using coolant instead of water during the entire year.
4. Select from a list methods of controlling the temperature of a heater.
5. Discuss in a short paragraph the operation of a heater.
6. Demonstrate the ability to:
    a. Pressure test a heater.
    b. Back flush a heater core.
    c. Remove and replace a water control valve.
    d. Test a blower motor for current draw.

HEATERS
UNIT II

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss procedures outlined on the job sheets.

   G. Give test.

II. Unit references:

   A. Crouse, William H. *Automotive Mechanics.* 7th ed. New York: McGraw-Hill Book Co., 1975.

   B. *Ford Service Manual.* Dearborn, Michigan: Ford Motor Co., 1975-76.

   C. *Chrysler, Plymouth, Dodge Chassis Service Manual.* Detroit, Michigan: Chrysler Corp., 1976.

   D. *Chevrolet Service Manual.* Detroit: Chevrolet Motor Div./General Motors Corp., 1977.

HEATERS
UNIT II

INFORMATION SHEET

I. Terms and definitions

  A. Heater core--Radiator type device used in the heater to pass hot water through to heat the air flowing through the heater

  B. Water control valve--Vacuum or manually operated valve which controls coolant flow in the heater core

  C. Heater plenum--Housing for the heater core, fan, and passageways for delivering air through the system

  D. Control system--Group of doors and deflectors operated by a vacuum system or manual linkage to control air flow in the heater-defroster system

  E. Defroster--Segment of the heater that deflects air to the windshield for thawing ice or vapors

  F. Blower--Motor-driven fan used to move air through the heater-defroster

  G. Thermostat (engine)--Device that maintains engine coolant temperature to a specified range, thereby providing the heater with hot coolant

II. Components of a heater (Transparency 1)

  A. Thermostat (engine)

  B. Heater hose

  C. Water pump (engine)

  D. Water control valve

  E. Heater plenum

  F. Defroster

  G. Control system

  H. Blower

  I. Heater core

INFORMATION SHEET

III. Reasons for using coolant instead of water throughout the year

  A. Eliminates corrosion

  B. Reduces possibility of air conditioning system freezing the heater core

  C. Extends life of cooling system components

  D. Allows system to operate at higher temperatures without boiling

IV. Methods of controlling heater temperature

  A. Control flow of coolant in heater core

  B. Control air flow through the heater core

  C. Mix outside air (cold air) with heated air

V. Heater operation (Transparency 2)

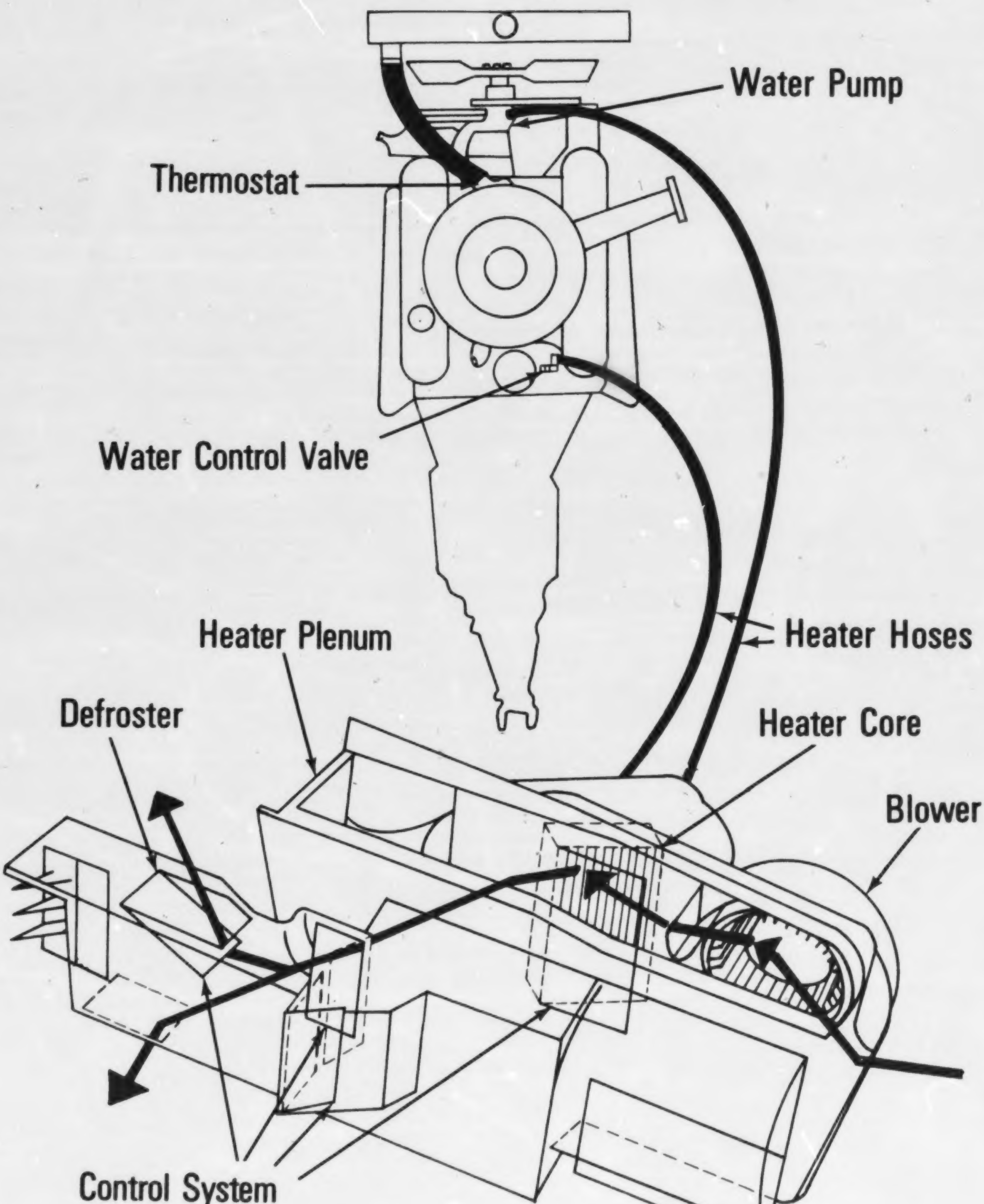
  A. Hot coolant is forced through the heater core by the water pump

  B. Heat from the coolant is conducted through the thin core metal and into the surrounding air

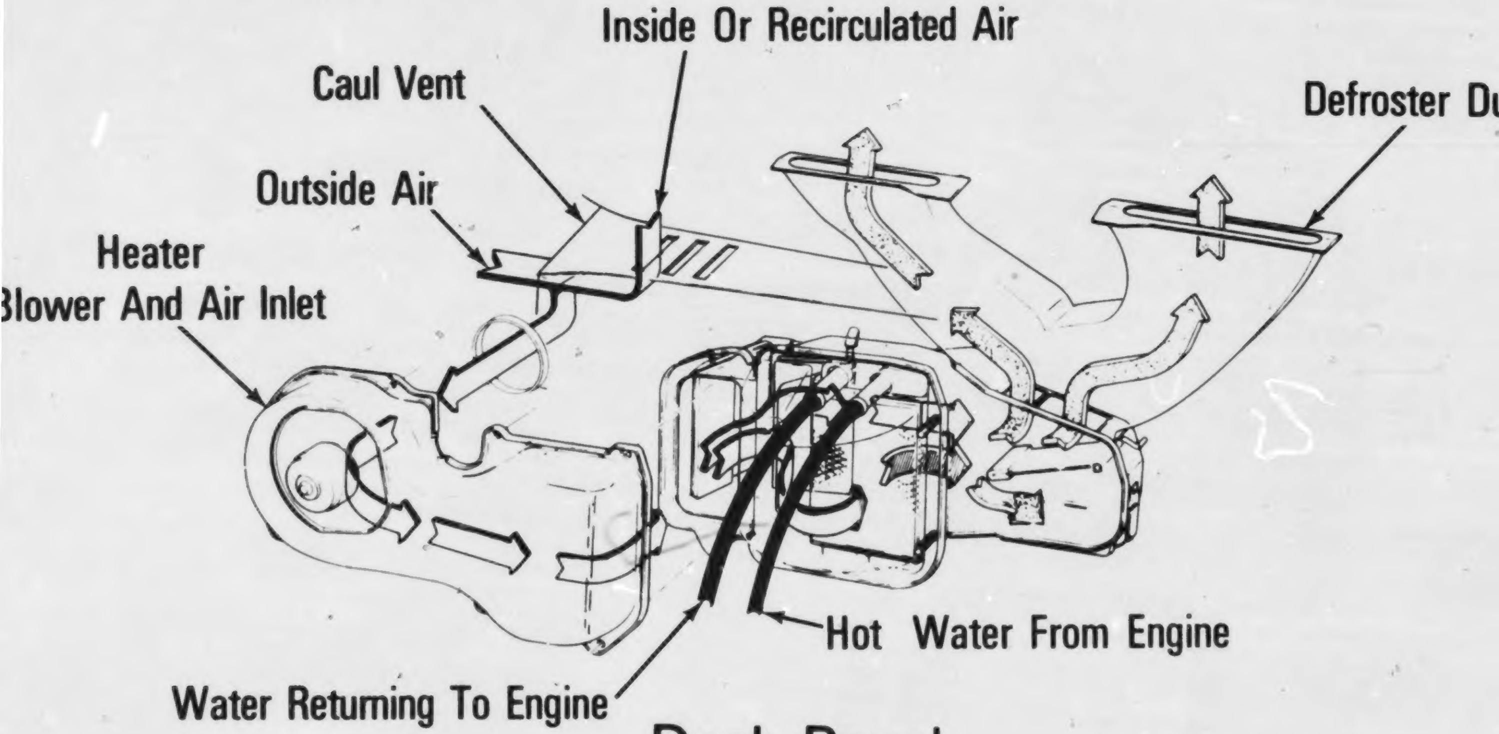
  C. Air around the core is moved across the core and into the passenger compartment by the blower through the heater plenum

  D. Air may be drawn in from outside or recirculated in the passenger compartment

Components of a Heater


Water Pump
Thermostat
Water Control Valve
Heater Hoses
Heater Plenum
Defroster
Heater Core
Blower
Control System

Heater Operation


Inside Or Recirculated Air
Caul Vent
Defroster Du
Outside Air
Heater
Blower And Air Inlet
Hot Water From Engine
Water Returning To Engine

Dash Panel

HEATERS
UNIT II

JOB SHEET #1--PRESSURE TEST A HEATER

I. Tools and equipment

   A. Radiator pressure tester

   B. Safety glasses

   C. Fender cover

II. Procedure

   A. Remove radiator cap

   (CAUTION: Never remove the radiator cap quickly when the engine is hot; hot coolant may be expelled and burn you.)

   B. Wipe the radiator neck clean

   C. Attach the radiator pressure tester

   D. Apply pressure (Figure 1)

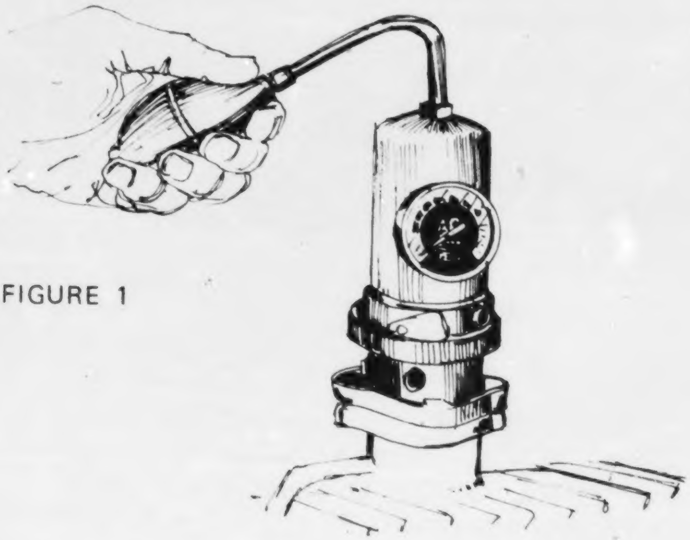


FIGURE 1

(NOTE: Pressure applied to the cooling system must not exceed recommended cooling system pressure by more than 1 psi [6.89 kPa].)

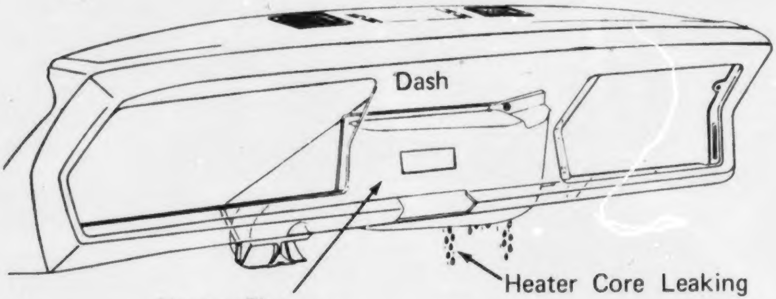
JOB SHEET #1

E. Inspect for leaks

1. Inspect all heater hoses and connections for leaks

2. Look inside the passenger compartment at the heater plenum lower section for coolant dripping from plenum seams (Figure 2)

FIGURE 2



(NOTE: If an oily fog is produced on the windshield while the heater and defroster are in operation, a leak in the heater core is indicated.)

3. Inspect for leaks at the heater water control valve

F. Release the pressure on the cooling system slowly

G. Remove radiator pressure tester

H. Repair any leaks

I. Retest

HEATERS
UNIT II

JOB SHEET #2--BACK FLUSH A HEATER CORE

I. Tools and equipment

   A. Back flush tool

   B. Basic hand tool set

   C. Safety glasses

   D. Fender covers

   E. Drain pan

II. Procedure

(NOTE: The process of back flushing a heater core is sometimes necessary to unplug the core if the heater has not had coolant circulating in it for some time, such as in the summer.)

   A. Remove radiator cap

   B. Drain radiator

   (NOTE: If coolant is rusty or dirty, the complete cooling system may need cleaning.)

   C. Remove the heater hoses at the connections on the engine

   D. Connect the back flush nozzle to the heater hose that was connected to the engine block (Figure 1)

JOB SHEET #2

E. Place the loose end of the heater hose, which was disconnected from the water pump housing, in a drain pan (Figure 1)

(CAUTION: Be sure to remove any valves in either hose.)

(NOTE: Operate the back flush tool according to manufacturer's directions.)

F. Back flush the heater core until the water coming from the hose in the drain pan is clean

(CAUTION: Back flush pressure should never exceed maximum radiator cap pressure by more than 1 psi [6.89 kPa].)

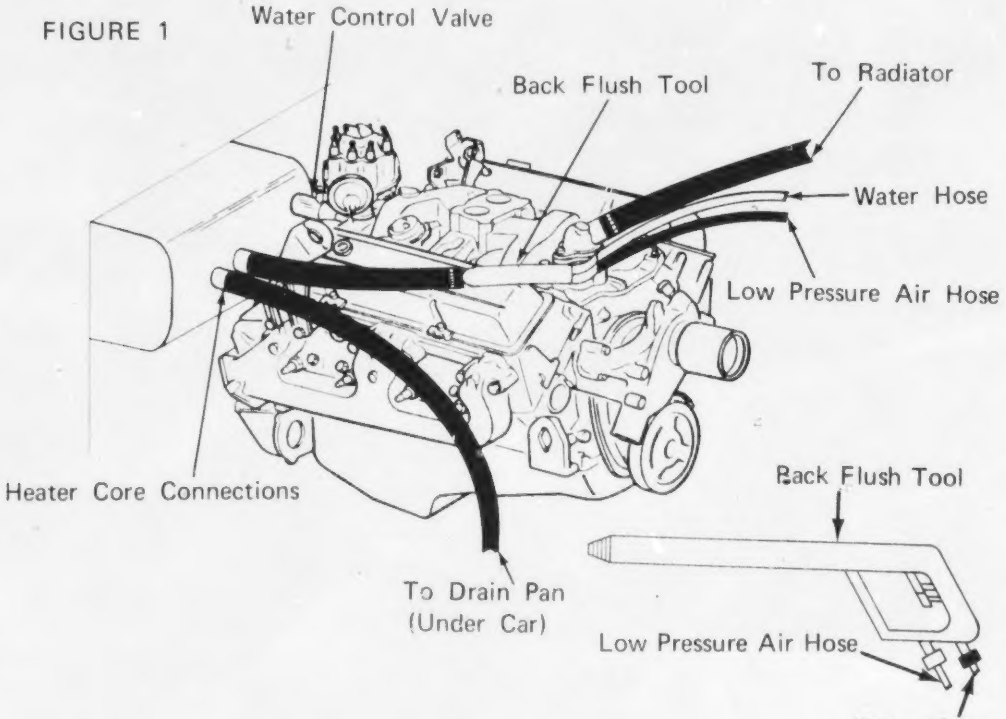
G. Remove the back flush tool

H. Reconnect the heater hose and any valves removed

I. Close radiator drain

J. Refill the cooling system with coolant

FIGURE 1


Water Control Valve
Back Flush Tool
To Radiator
Water Hose
Low Pressure Air Hose
Heater Core Connections
Back Flush Tool
To Drain Pan (Under Car)
Low Pressure Air Hose
Water Hose

HEATERS
UNIT II

JOB SHEET #3--REMOVE AND REPLACE A WATER CONTROL VALVE

I. Tools and materials

   A. Basic hand tool set

   B. Fender covers

   C. Drain pan

   D. Safety glasses

II. Procedure

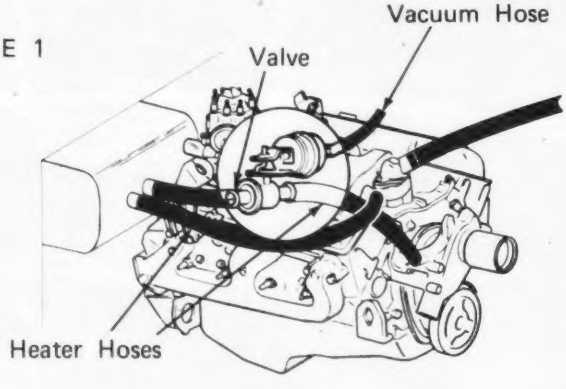
   A. Remove radiator cap

   (CAUTION: Open the cap slowly if the radiator is hot to prevent being burned.)

   B. Drain radiator

   C. Remove any accessories necessary to gain access to the water control valve, such as air filter or wiring (Figure 1)

FIGURE 1



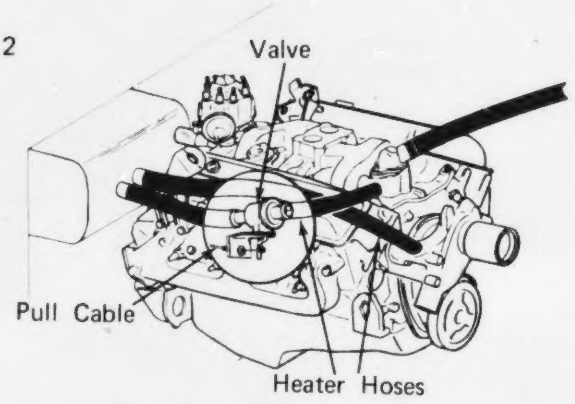
   D. Disconnect valve actuator

      1. Remove the vacuum hose on the vacuum-operated valve

JOB SHEET #3

2. Remove the pull cable on the manually operated valve (Figure 2)

FIGURE 2



E. Disconnect heater hoses from the valve

F. Remove the retaining screws from the valve to remove it

(NOTE: On some models remove valve by unscrewing it from the engine.)

G. Reattach the valve in the reverse of removing it

H. Connect heater hoses

I. Connect valve actuator

J. Close radiator drain

K. Fill cooling system with coolant

L. Check for leaks

M. Reinstall any accessories removed to gain access to the control valve

N. Start engine

O. Recheck coolant level

P. Recheck for water leaks

HEATERS
UNIT II

JOB SHEET #4--TEST A BLOWER MOTOR FOR CURRENT DRAW

I. Tools and equipment

A. Basic hand tool set

B. Volt-ammeter

C. Safety glasses

D. Fender covers

E. Assortment of jumper wires

II. Procedure

(NOTE: A current draw test is used to help determine the condition of the motor and wiring circuit. A high current draw will indicate an overload on the motor caused by either dry bearings or electrical problems. Either way, the motor will have to be removed and repaired or replaced.)

A. Raise the vehicle hood

B. Install fender covers

C. Disconnect the battery cables

D. Clean the cable and post of corrosion

E. Reconnect battery cables

F. Test the battery for serviceable condition

(NOTE: Specific gravity should be 1.225 or higher.)

JOB SHEET #4

G. Locate the blower motor lead wire (Figure 1)

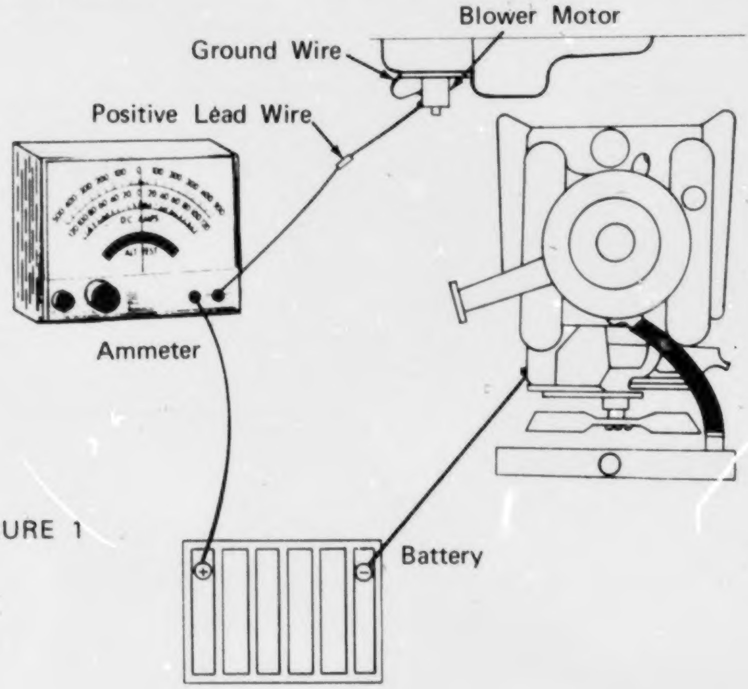

Blower Motor
Ground Wire
Positive Lead Wire
DC AMPS
ALT TEST
Ammeter
Battery

FIGURE 1

H. Connect ammeter leads between positive battery post and lead from motor while observing correct polarity

I. Take ammeter reading

(NOTE: If the readings are higher than specifications, remove the motor for repair or replacement.)

J. Disconnect ammeter

HEATERS
UNIT II

TEST

NAME ____ SCORE ____________________

1. Match the terms on the right to the correct definitions.

______a. Radiator type device used in the heater to pass hot water through to heat the air flowing through the heater

______b. Vacuum or manually operated valve which controls coolant flow in the heater core

______c. Housing for the heater core, fan, and passageways for delivering air through the system

______d. Group of doors and deflectors operated by a vacuum system or manual linkage to control air flow in the heater-defroster system

______e. Segment of the heater that deflects air to the windshield for thawing ice or vapors

______f. Motor-driven fan used to move air through the heater-defroster

______g. Device that maintains engine coolant temperature to a specified range, thereby providing the heater with hot coolant

1. Control system
2. Heater plenum
3. Defroster
4. Blower
5. Thermostat (engine)
6. Heater core
7. Water control valve

2. Identify the following components of a heating system by writing the correct names in the blanks provided.

a. ______________________

b. ______________________

c. ______________________

d. ______________________

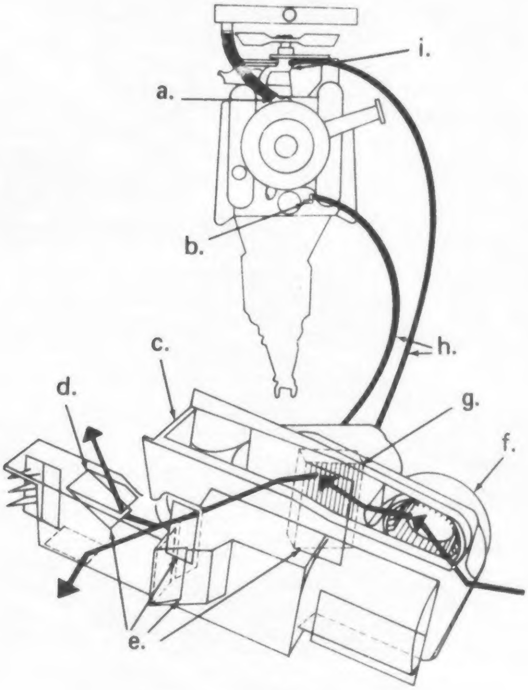
e. ______________________

f. ______________________

g. ______________________

h. ______________________

. ______________________



3. List four reasons for using coolant instead of water during the entire year.

a. ____

b. ____

c. ____

d. ____

4. Select from the following list methods of controlling heater temperature by placing an "X" next to the correct items.

   ______a. Control flow of coolant in heater core

   ______b. Open or close the vent slightly

   ______c. Mix outside air (cold air) with heated air

   ______d. Install a cover on the radiator

   ______e. Control air flow through the heater core

5. Discuss heater operation.

   ____

   ____

   ____

   ____

6. Demonstrate the ability to:

   a. Pressure test a heater.

   b. Back flush a heater core.

   c. Remove and replace a water control valve.

   d. Test a blower motor for current draw.

   (NOTE: If these activities have not been accomplished prior to the test, ask the instructor when they should be completed.)

HEATERS
UNIT II

ANSWERS TO TEST

1. a. 6
   b. 7
   c. 2
   d. 1
   e. 3
   f. 4
   g. 5
2. a. Thermostat (engine)
   b. Water control valve
   c. Heater plenum
   d. Defroster
   e. Control system
   f. Blower
   g. Heater core
   h. Heater hoses
   i. Water pump (engine)
3. a. Eliminates corrosion
   b. Reduces possibility of air conditioning system freezing the heater core
   c. Extends life of cooling system components
   d. Allows system to operate at higher temperatures without boiling
4. a, c, e

5. Discussion should include:
    a. Hot coolant is forced through the heater core by the water pump
    b. Heat from the coolant is conducted through the thin core metal and into the surrounding air
    c. Air around the core is moved across the core and into the passenger compartment by the blower through the heater plenum
    d. Air may be drawn in from outside or recirculated in the passenger compartment
6. Performance skills evaluated to satisfaction of instructor